GEOLOGICAL SURVEY OF ALABAMA

EUGENE ALLEN SMITH, STATE GEOLOGIST.

INDEX TO

The Mineral Resources

OF ALABAMA.

BY

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AND

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1. Report of progress for 1874; On the Metamorphic Region of Alabama. Eugene A. Smith 139 pages. Out of print.

2. Report of Progress for 1875. Paleozoic Formations of Coosa Valley. Eugene A. Smith. On Coal Mining in Alabama, T. H. Aldrich. 220 pages. Postage, 5 cents.

3. Report of Progress for 1867. Paleozoic Formations of Roup's Jones', and Cahaba Valleys; Eugene A. Smith, with map; Fresh Water and Land Shells, Lewis. 100 pages. Out of print.

4. Report of Progress for 1877-78; On the Tennessee Valley, Brown's Valley, and Warrior Coal Basin; 4 county maps; Eugene A. Smith. 159 pages. Out of print.

5. Report of Progress for 1879-80. Resources of the Warrior Coal Field, between Tuscaloosa and Sipsey Fork. 2 maps. Eugene A. Smith. Tennessee Valley North of the River; Henry McCalley. 158 pages. Out of print.

6. Report for the years 1881-82. Agricultural Features of Alabama; maps and illustrations; Eugene A. Smith. 615 pages. Out of print.

7. Report on the Warrior Coal Field, 1886; Henry McCalley. 571 pages. Out of print.

8. Bulletin No. 1, Fossils of the Tertiary Formation; T. H. Aldrich and O. Meyer, 1886; 9 plates. Out of print.

9. Fresh Water and Marine Crustacea of Alabama; 8 plates; 56 pages, 1888; C. L. Herrick. Out of print.

10. Report on the Cahaba Coal Field; Joseph Squire. Appendix, Geology of Adjacent Valleys; Eugene A. Smith. Maps, 6 plates and many cuts; colored sections; 189 pages; cloth, 1890. Postage, 11c.

11. Coal Measures of the Plateau Region of the Warrior Field; H. McCalley; A. M. Gibson; map and colored sections; 238 pages, 1891. Postage, 5 cents.

12. Bulletin No. 2; On the Phosphates and Marls of Alabama; Eugene A. Smith; 82 pages; 1892. Edition Exhausted.

13. Bulletin No. 3; On the Lower Gold Belt; Wm. B. Phillips; map and illustrations; 97 pages; 1892. Edition exhausted.

14. Bulletin No. 4; Geology of Northeast Alabama and adjacent parts of Georgia and Tennessee; C. W. Hayes; map and illustrations; 85 pages; 1892. Postage, 3 cents.

15. Report on Murphree's Valley; A. M. Gibson, one section, 132 pages; 1893. Postage, 3 cents.

16. Coal Measures of Blount Mountain; A. M. Gibson; map and sections; 80 pages; 1893. Edition exhausted.

17. Geological Map of Alabama with Explanatory Chart; 1893. Edition exhausted.

18. Geology of the Coastal Plain of Alabama; Eugene A. Smith, L. C. Johnson, D. W. Langdon, and others; many sections and other illustrations; 760 pages; 1894. Postage, 18 cents.

19. Report on the Coosa Coal Field; A. M. Gibson; with section; 143 pages; 1895. Postage, 4 cents.

20. Bulletin No. 5; On the Upper Gold Belt; W. M. Brewer; with notes on the most important Rock Varieties; E. A. Smith; G. W. Hawes, J. M. Clements, and A. H. Brooks; 202 pages; 1896. Postage, 5c.

21. Report on Iron Making in Alabama; Wm. B. Phillips; 164 pages; 1896. Edition exhausted.

22. The Valley Regions of Alabama; Henry McCalley.

Part I. On the Tennessee Valley Region; 436 pp; 1896; p. 10c.

Part II. On the Coosa Valley Region; 862 pages; 1897; p. 20c.

23. Report on Iron Making in Alabama; Second Edition; Wm. B. Phillips. 380 pages. 1898. Edition exhausted.

24. Warrior Basin Report and Map; Henry McCalley; $1.00. Map in separate envelope. Numerous folding sections. 327 pages. 1900. Postage, 16 cents.

25. Bulletin No. 6; Preliminary report on the Clays of Alabama, with Chemical analyses and Physical tests of some of the more important; Dr. Heinrich Ries. 220 pages. 1900. Postage, 8 cents.

26. The Plant Life of Alabama; an account of the distribution, modes of association, and adaptions of the Flora of Alabama; together with a systematic Catalogue of the Plants growing in the State without cultivation, by Charles Mohr, PhD. Cloth. Map and two portraits. 921 pages. 1901. Postage, 33 cents.

27. Bulletin No. 7; Preliminary Report on a part of the Water Powers of Alabama, B. M. Hall. Maps and illustrations. 188 pages. 1903. Postage, 6 cents.

28. Bulletin No. 8; Preliminary Report on the Cement Resources of Alabama. Eugene A. Smith. Postage, —

29. Bulletin No. 9; Preliminary Report on the Artesian and Other Underground Waters of Alabama. Eugene A. Smith. Postage, —

30. Index to the Mineral Resources of Alabama. E. A. Smith and Henry McCalley. Maps and illustrations; 79 pages. 1904. Postage, 3 cents.

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TABLE OF THE GEOLOGICAL FORMATIONS OF ALABAMA.

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CHAPTER I.

MATERIALS USED IN IRON MAKING, AND ASSOCIATED MINERALS.

It is fitting that a document which treats of the Mineral Resources of Alabama, should begin with an account of those concerned in that Industry which has done so much to give to this state its present commanding position in the industrial world, viz., Iron Making.

THE ORES.

The iron ores of Alabama in the order of their economic importance are (1) The Red Ore or Hematite, (2) The Brown Ore or Limonite, (3) The Gray Ore or Magnetite, and (4) Black Band and Clay Iron Stone. Only the two first have been mined on any large scale.

These ores are used in the manufacture of pig iron for foundries, mills and pipe works, and for making basic iron for open hearth steel plants. As a rule, they are too high in phosphorus for making Bessemer steel.

Practically all the ore mined in Alabama is smelted in the state, the shipments out of the state being about equal to what is received from other states.

Alabama stands third in iron ore production among the states of the Union. The product for 1902 was 3,574,474 long tons, which was a little over ten per cent. of the iron ore mined in the United States. This output had a value at the mines at $1.10 per ton, of $3,936,812. This valuation is less than that obtaining in any other state except Texas, the average in the United States being about $1.84 per long ton.

There are 42 coke furnaces and 6 charcoal furnaces in operation in the state. The charcoal furnaces are gradually going out of blast, and will soon be a thing of the past.

In pig iron production Alabama ranks fourth among the states of the Union. This high rank, which will probably soon be exceeded, is due in great measure to the close proximity of the ore, the stone, and the coal needed for the production of the iron. At many points in the Birmingham District these three essentials are obtained within a radius of six miles of the furnaces.

(1.) RED ORE, OR HEMATITE:—While Hematite occurs in Alabama in several geological formations, it is only in the Upper Silurian that it is in sufficient quantity to be of great commercial value. This, the Red Mountain, or Clinton ore, is otherwise known as Dyestone ore, Fossiliferous ore, Oolitic ore, etc. It is the most important iron ore in the state because of its great quantity, the low cost with which it may be mined, its reliability, and its close proximity to the coal and stone used in the manufacture of iron. The output of red ore for 1902 was 2,565,635 long tons, making about 72 per cent. of the iron ore product of the state.

The Red Mountain ridges occur normally on each side of the anticlinal valleys which separate the Coal areas from each other, and are distinguished as East Red Mountain and West Red Mountain. In places the red ore ridges are lacking on one side of the valleys, usually the western side, being cut out by faults, while on the other hand the ridge may be duplicated on one side by the same cause. This *formation* occurs also in the much disturbed strata east of the Coosa Coal Field, in ridges of sandstone and conglomerate which carry no red ore.

In most of the valley occurrences, the moderate dips of the strata are on the eastern side, and the steep dips and faults are on the western side. Murphree's Valley makes an exception to this, the faults and vertical measures being on the eastern side. It is usually the case also that the ore bed shows the highest angle of dip at the outcrop, and that the dip rapidly decreases as the bed is penetrated.

The iron occurs mainly in the central part of the formation, in seams or beds, one to five in number, which vary in thickness from a few inches to thirty feet.

While the ore seams are very persistent along the outcrop, which in Alabama must be as much as 50 miles, yet they vary greatly from place to place, being either too thin or too lean for profitable working in by far the greater part of this distance.

Plate I—Outcrop of Red Mountain Ore Seam, at Ishkooda, Jefferson County

Much mining of red ore has been done near Gate City, Village Springs, Springville, Attalla, Gadsden, Round Mountain, Gaylesville, Ft. Payne, Valley Head, etc., but the most important development of the Clinton ore in the state and in the world, is along the 15 or 16 mile stretch of the East Red Mountain between Birmingham and Bessemer, and there is a practically continuous series of mines, and strippings for this entire distance. The ore here is in three different seams, but the upper fifteen feet of the *Big Seam* or *Red Mountain seam,* have furnished almost the entire supply of ore to the 23 furnaces of the district.

Plate I shows the outcrop of this seam near Birmingham.

In a large part of this stretch of Red Mountain, the ore has been gained by stripping down to where the cover becomes fifteen or twenty feet thick over the ore and too expensive to remove.

Most of the ore, however, is obtained from well developed deep mines going down on the slope of the bed. These mines are equipped with all the latest and most improved devices for the cheap handling of the ore. The deepest of these mines at the present time has gone down on the dip of the bed a distance of 1850 feet from the outcrop. The ore is brought by small mine cars from the different entries to the main slope and there emptied into a skip holding from 12 to 14 tons. The skips are hauled to the surface by steam power, the ore is dumped automatically into the crushers and thence into the railroad cars. This arrangement very greatly increases the handling capacity, and is intended to work to a depth of about a mile. When fully equipped the Red ore mines of the Tennessee Coal, Iron and Railroad company alone will have a capacity estimated at 10,000 tons a day.

The ore of the Big Seam improves in quality towards the southwest, the percentage of lime increasing while that of silica decreases. The percentage of alumina remains about constant, but on account of the coming in of slate partings, more care has to be exercised in the mining.

The lower and major part of the Big Seam has not been worked except very sparingly at the outcrop, being too siliceous, with the silica increasing from top to bottom of the seam.

Experiments carried out by Dr. Wm. B. Phillips for the Tennessee Company, have fully demonstrated the practicability of reducing the relative proportion of silica by magnetic concentration, so that the entire thickness of this great seam will one day be utilized, and the same may be said of the siliceous ores of other parts of the state.

The other seams of the Red Mountain Ore, viz., the *Irondale Seam* below the Big Seam, and the *Ida seam* above it, have been worked at places along the East Red Mountain from opposite Birmingham towards the northeast; the ore is softer than that of the Big Seam, carrying sometimes over 50 per cent. of metallic iron. The Ida seam, where worked, yields a compact ore five or six feet thick, with 30 to 35 per cent. of metallic iron.

In most of the smaller mines the mine cars are hauled to the surface; the miners are paid by the car load (about two tons), the tracks being kept up by the company.

Without any reference to the actual hardness of the ore, the leached red ore containing very little lime is called *soft ore,* and the unleached or limy ore, *hard ore.*

The soft ore is usually hard enough to necessitate blasting and crushing. As a rule it extends down on the dip a distance of 150 to 200 feet from the outcrop, though on the one hand it sometimes extends 300 feet, and on the other hand, in places the hard ore sets in at the outcrop; the amount and depth of the soft ore apparently being more or less determined by the cover. The transition from the one variety to the other is usually abrupt, but the line of contact is irregular, the soft ore extending in points down into the hard ore. Moreover, the soft ore often includes boulders and pockets of the hard ore, and occasionally "horses" of ferruginous sandstone. Both ores are quite contsant in composition away from the line of contact.

The *soft ore* is limited in quantity but this does not signify much, is it is being less and less used in the furnaces. It is usually a mass of smooth, rounded, and flattened grains of quartz of the size of bird shot and smaller, coated with hematite and cemented together by the same material. Its average composition as shown by stock house analyses extended over many years, is about as follows: Silica or insoluble matter 27 per cent; Metallic iron 46 per cent; Water 7 per cent; Phosphorus 0.30 per cent. to 0.40 per cent. and a little lime.

The main dependence of the furnaces of the Birmingham district is the *hard ore.* In the mines it always sets in at the water level, holding its own as to thickness and composition, to the bottom of the deepest mine, 1850 feet, and as far as tested by borings, at least 3,500 to 4,000 feet to the southeast from the outcrop; there seems thus to be no reason for anticipating any adverse change in the ore within the depth to which mining operations are likely to be carried.

When the hard ore carries about equal amounts of silica and lime it is self-fluxing, and under these conditions it has been used alone in the furnaces. Usually, however, it contains more lime than is necessary for self-fluxing, in which case, a little soft ore, or brown ore, or both are added.

At the present time the soft ore makes seldom over ten per cent of the ore burden, though in some of the furnaces it makes half of the burden. From stock house samples the composition of the hard ore is shown to be about as follows: Silica, 13.4 per cent.; Metallic iron, 37 per cent.; Lime, 16.20 per cent.; Alumina, 3.18 per cent.; Phosphorus, .37 per cent.; Sulphur, .07 per cent.; Carbonic acid, 12.24 per cent.; Water, 0.50 per cent.

Red Hematite occurs in Alabama also in the Trenton formation, where it is very similar in quality and appearance to the soft red ore of the Clinton. And in the Cambrian formation still lower in the geological column, it has been observed in stratified seams from 18 inches to 5 feet in thickness.

The Cambrian ore is of the crystallized or specular variety, and may some day be utilized. The known occurrences of it are few in number and none of them has as yet been fully tested.

(2.) Brown Ore or Limonite. — This ore, the second in importance of the iron ores of Alabama as well as of the United States, furnished only 9.3 per cent of the total iron ore production of the United States in 1902. Of this, Alabama produced 28 per cent, 1,008,839 long tons, and the state leads in this industry.

In the early days of iron making and up to the year 1876 this was the only ore used in the catalan forges, bloomaries, and charcoal furnaces of the state. It was then demonstrated

that good iron could be made at low cost from the red ores, with coke for the fuel.

In general the limonites are considered the best of the ores of Alabama and they command the highest prices and command a ready sale.

The usual mode of occurrence is in irregular masses of concretionary origin in the residual clays resulting from the decomposition of limestones, and as a consequence the mining is uncertain and expensive. Limonite also occurs in regularly stratified seams or beds, and then it is the result of the alteration of pyrites or of carbonate ores. Practically all of the brown ore actually mined is that occurring in the residual clays above mentioned. Most of the ore before going to the furnace is washed and screened, and this manipulation, together with the cost of mining, makes it the most expensive of the iron ores, and it is therefore seldom used alone, but is usually mixed with the red ore in proportions determined by the quality of the iron desired. It is used alone in the charcoal furnaces and also in the coke furnaces when a particularly tough pig iron is wanted. Usually the brown ore constitutes about 20 per cent of the ore burden. This addition of brown ore to the red, besides taking care of the excess of lime in the hard red ore, causes a smoother and more uniform flow in the furnace burden, lessening the danger from hanging or shelving.

In a few places a manganiferous limonite occurs, and small quantities of it have been used in the production of spiegeleisen, and ferro-manganese.

The limonite deposits are very numerous and are distributed over a broad expanse of country and in many places are known to be very extensive. In some of the deposits the ore is in nearly solid mass, in others it is much scattered, and in consequence the amount of foreign material necessary to be moved for every ton of ore produced, varies very much, not only in the different ore banks but also in the different parts of the same bank. The mining is in irregular diggings and open cuts, and is mostly done by contract, costing about 75 cents on an average to mine, and bringing about $1.00 per ton at the furnace

Among the varieties of brown ore are the compact, the honey comb, and the ochreous or earthy ores. The pocket ore is

nearly always associated with "horses" of clay often pure white and plastic. It is also sometimes mixed with foreign matters such as loose chert, and fragments of sandstone and conglomerate.

The deposits occur in nearly all the geological formations of the state, but in most of these the ore is either insufficient in quantity or not pure enough to be of much commercial value. The most important of the deposits, in point of extent and value, occur in the following formations, viz., the Knox Dolomite and the Weisner Quartzite, the Lauderdale Chert of the Lower Carboniferous, and the Lafayette. Some extensive beds of ore of inferior quality generally, occur also on the Tuscaloosa formation of the Cretaceous, and in the upper part of the Lower Carboniferous and in the Metamorphic rocks.

The Lafayette.—This ore is widely distributed, but does not occur in many places in sufficient quantity and of such quality as to justify working. It is the principal ore of the northern part of the state in the counties of Colbert, Franklin, Marion and Lamar.

Loose boulders scattered over the surface supplied the first furnace in Alabama, which was built in 1818 on Cedar Creek in Franklin county. A Catalan forge must also have been at the same place for lumps of malleable, as well as of cast iron, are to be found around the old furnace ruins.

The furnaces of Sheffield and Florence use this ore without admixture with other ore. Many of the deposits are on high ground and are comparatively shallow, as shown by the diggings extending down to the underlying bedded rocks. Other deposits in lower situations are 50 and 60 feet and more in depth. The ore is mostly a dark colored compact ore, but in in some of the deposits it is of concretionary nature with red and yellow ochres filling the cavities. It occurs in a red sandy loam usually along with rounded pebbles of quartz and often with ferruginous sandstone and conglomerate. This ore, while occurring in the surface red loams of the Lafayette, probably has its source in the Lower Carboniferous limestones and possibly also in part in the stratified seams at the base of the Coal Measures.

In the banks the ore often makes 25 to 30 per cent of the entire mass. It is of good quality as is shown bv the following average analysis of washed ore furnished to the Sloss-Shef-

field furnaces from the numerous banks about Russellville: Metallic iron 53.67 per cent; Alumina 5.58 per cent; Silica 8.52 per cent.; Phosphorus, 0.33 per cent. It is said to work well in the furnace and to yield an unusually good quality of pig iron, that seldom runs higher than 0.60 per cent of phosphorus and 0.50 per cent of silicon.

The Lauderdale Chert:—The ore of this formation is in stratified seams and pockets. The former are probably the weathered outcrops of carbonate and the pocket ore also, in part at least, from the weathering and breaking down of the stratified seams.

The stratified ore in one or two seams may in some localities be traced for miles where it is too thin or too cherty to be of commercial value. At intervals along these outcrops there are some extensive deposits of boulder, nodular and gravelly ore of good quality, though as a rule inferior to the limonites of some of the other formations. It has never been extensively worked in Alabama. Some of the limonites of this formation are highly manganiferous.

The Knox Dolomite:—The brown ore of the Knox Dolomite is the most abundant, has been extensively mined and, in general, is the best of the iron ores of the state. Some of the deposits have been worked to depth of 100 feet with ore still at the bottom.

The most important deposits and mines are in Cherokee, Calhoun, Talladega, Shelby, Bibb, Tuscaloosa and Blount counties. The ore is found in irregular pockets in the red clay resulting from the decomposition of the limestone of the formation, and while mostly of good quality, high in iron and low in silica and phosphorus, it is sometimes rough and cherty and sometimes a black waxy ore, high in phosphorus. The cherty ore is usually in large boulders, sometimes occurring in rows as if outcrops of stratified ledges.

The view in Plate II of an open cut at Greeley in Tuscaloosa county, illustrates well the mode of occurrence and method of mining the brown ore.

The average composition of the dried ore, as shown by many analyses is, Metallic iron 51.00 per cent; Silica 9 per cent; Alumina 3.75 per cent; Lime 0.75 per cent; Phosphorus 0.40 per cent, and Sulphur 0.10 per cent.

Plate II—Greely Open Cut Brown Or

n Ore Mine, Goethite, Tuscaloosa County.

The charcoal furnaces of the state are wholly supplied with this ore.

The Weisner Quartzite:—The deposits of this formation are numerous and extensive, and are either the outcrops of one or more stratified seams, or a pocket ore derived in part at least from the weathering and breaking down of the stratified seams.

The stratified ore outcrops near the crests of the mountains, (Weisner), while the pocket deposits are mostly near the base of the mountains or along fault lines. The former deposits are very variable, attaining sometimes considerable size, being as much as several hundred yards in length and forty to fifty feet thick. The pocket ore comprises some of the most extensive brown ore deposits in the state. The ore itself is somewhat variable, being in part a black waxy ore high in phosphorus, in part a mixture of very good ore with a highly siliceous or sandy ore.

For this reason the mining is sometimes tedious and expensive because of the necessity of separating the good from the bad. These siliceous or sandy ores are in very large quantities and will no doubt some day be utilized after being concentrated by magnetic process.

(3.) THE GRAY ORE OR MAGNETITE:—This ore occurs in the upper part of the Weisner Quartzite formation in Talladegt county. It is in several stratified seams, one to four, varying in thickness from two to eight feet.

While these seams of ore are generally highly siliceous and hardly more than dark gray sandstone with sparingly disseminated grains of magnetite, yet in places the ore carries as much as 80 per cent of magnetite and only 17 to 18 per cent of silica.

The ore is sometimes massive in structure sometimes laminoted and almost fibrous, breaking up on weathering into fragments that resemble chips of wood. The magnetite is also sometimes in thin scales or plates making a kind of specular ore high in titanium.

The Talladega magnetite has been somewhat extensively investigated and considerable amounts have been raised and furnace tests made, and it is probable that this desirable ore will soon be added to the list of our commercially important resources.

Considerable magnetite has been observed at a number of points in the region of our metmorphic rocks, but as yet not in sufficient quantity to be commercially used.

(4.) BLACK BAND AND CLAY IRON STONE:—The black band is a highly carbonaceous variety of the carbonate ore, occurring at a number of points in the Coal Measures. It has been mined or quarried at only a few places and then only to a very limited extent. Some experiments have been made with it in the furnaces both in the raw and calcined state.

The Clay iron stone occurs in regular seams and in rounded and flattened concretions in the strata of the Coal Measures, and also in the lower Cretaceous and in the Tertiary formations, in none of which, however, has it yet been demonstrated to be of any commercial importance. As result of the weathing and disintegration of this ore are found occasionally some very good deposits of limonite or brown ore.

In connection with iron ores two closely associated minerals may appropriately be described, viz., manganese ores and bauxite.

Manganese Ores.

Pyrolusite and Psilomelane occur in a number of localities in Cleburne, Calhoun, Blount and Cherokee counties in quantity sufficient to make them of probable commercial value.

Several of these deposits in the Weisner formation in Cleburne county have been worked and have furnished probably the greater part of the pure manganese ore that has been mined in the state.

Manganiferous limonite has been mined to some extent near Anniston and converted into *spiegel eisen* and *ferro-manganese* in the Anniston furnaces.

In its mode of occurrence manganese ore is very similar to brown iron ore, with which it is closely associated, most of the brown ore banks containing more or less of it, and it often happens that the same deposit is partly limonite and partly manganese ore. The Blount county deposits of this kind are near the base of the Fort Payne chert of the Lower Carboniferous, those of Cherokee, Tuscaloosa and other counties are in the Knox Dolomite.

Bauxite.

This ore, a hydrate of alumina, is much used as a source of the metal aluminum and of some of its compounds, mainly alum. In this state it occurs, mainly in the Knox Dolomite and in the Weisner Quartzite formations, in irregular deposits along a narrow belt extending from the Georgia line southwestward as far as Anniston. All the deposits thus far known are in the counties of Cherokee, Cleburne, Calhoun and DeKalb, but they are too irregular in their occurrence and have been too little investigated to admit of any close approximation to the quantity of the ore.

The ore is commonly concretionary or pisolitic though sometimes compact, homogenous and fine grained, and the best quality is of gray to white colors. Much of it has iron oxide replacing part of the alumina with the result of giving a reddish and mottled appearance to the ore.

Associated with the true bauxite are mixtures of clay and bauxite in varying proportions, and in places irregular streaks or bands of pure halloysite occur in the midst of the bauxite. The bauxitic clays above mentioned are exceedingly refractory and have been suggested as suitable material for the manufacture of fire brick.

The mode of ccurrence of the bauxite is very similar to that of limonite, in irregular and ill defined pockets, and in some of the limonite banks about Rock Run in Cherokee county, the iron ore appears to grade into the bauxite, and both ores have been obtained from the same digging. Other associations with the bauxite are white china clay and lignite, both of which occur in a bauxite-limonite bank near Rock Run. Manganese ores have also been observed in connection with the bauxite.

The bauxite is obtained from open cuts and pits which are in places 60 to 70 feet deep. It is easily mined, being rather soft below the surface. After sorting and concentrating by screen and hand, it is spread out under shelter and dried by artificial heat before sending to the market, rotary driers being most commonly used. Only the very highest grade of the ore is sold, the lower grades being thrown aside for the present, but the time will probably come when it will all be used in the manufacture of fire brick, as well as of aluminum compounds

of various kinds. In the year 1903 only about 6,262 long tons of bauxite were mined in Alabama, as the works were mostly in that part of the deposit lying within the Georgia line. The principal markets are New York, Philadelphia, Pittsburg, Buffalo, Syracuse, Lockport, etc., where are located the aluminum and alum manufactories; and some of the best quality was exported to Germany.

Fuller details concerning the iron and manganese ores and bauxite may be found in the Reports on Murphree's Valley, and on the Valley Regions, Parts I and II, and in the report of Iron Making.

THE COAL.

The termination towards the southwest of the great Appalachian Coal Field, embraces an area in Alabama of about 8,800 square miles.

This area is in three distinct fields separated from each other by narrow anticlinal valleys in which the limestones, iron ores, etc., of older formations than the Coal Measures make the surface. From the main streams which drain them, these fields have been named the Warrior, the Cahaba and the Coosa.

In all three fields the strata have a general dip or pitch towards the southwest, and each is a trough with its axis near the southeastern border; thus the greatest thickness of the measures will be in each field, near the eastern border and at or towards the southwestern end.

The maximum thickness of these measures will not fall short of 4,000 feet. The coal seams vary in thickness from a few inches up to 16 feet, but the thick seams are always more or less shaly. About 25 of these seams have a thickness of 18 inches upwards and have been worked.

Previous to 1874 it has been estimated that the total coal production of Alabama did not exceed 480,000 tons, the earliest mining operations having been carried on in the "forties," in the Trout Creek and Broken Arrow regions of the Coosa field, and in the Montevallo district of the Cahaba field. Since 1874 the production has increased rapidly and in 1903 it was, according to the report of the State Mine Inspector, 11,700,753 tons, valued at about $15,000,000, Alabama ranking fifth among the coal producing states of the Union.

Between two hundred and fifty and three hundred mines on about twenty-five different seams have furnished this coal. These mines vary in annual production from 2,000 to 418,000 tons; more than half of them are drifts with natural drainage; about one third are slopes, and only seven are shafts, the deepest of which is 230 feet. The larger mines are provided with the most modern equipments for mining and raising the coal. The pillar and stall system is the mining method most in use, but the long wall system has been adopted in some cases.

In the year 1903 coal mining gave employment to 12,876 miners and 5,230 day men, using about 100 mining machines in 13 mines. The mines are comparatively free from fire damp which has been detected in about one fourth of them.

The Alabama coals are all bituminous coals, and of quality, as shown by chemical analyses and the practical tests of use, to compare favorably with the coal of other states. By the use of improved shaking screens the coal as mined is separated into lump, nut and slack. The two first go to the general market for steam and domestic purposes, while the slack after washing is used mostly for making coke for the iron furnaces, though some of it is used for blacksmithing. Within the last few years a good deal of *run of mines* from several different mines has been shipped to Demopolis and there used in the rotary kilns of the portland cement plant, for which purpose it has been found to be well adapted.

The principal markets for the coal are within the state, but much of it goes to South Carolina, Georgia, Tennessee, Missippi, Louisiana and Texas; to the steamships at Mobile, Pensacola, New Orleans and Savannah; and to the export trade, chiefly to Mexico.

The home supply is used mainly for manufacture of coke for the iron furnaces, while the commercial shipments are mostly of steam coal which is suplied to almost every railroad in the South.

The growth of the Coke industry in Alabama has been even more rapid than that of the coal mining. It was not until 1876 that it was known that the Alabama Coal would make coke suitable for iron smelting, and the state ranks now second in the Union as a coke producing state.

The coke production in 1903, as given in the Alabama State Mine Inspector's Report, was 2,568,185 tons. The

greater part of this coke was used in the iron furnaces of the state, though a portion of it was shipped to other states and to Mexico, for smelting and foundry purposes. The present product does not begin to supply the demand and many new ovens are in course of construction. The coke in 1903 was made in about 8,638 ovens, all of the bee hive pattern except about 240 Semet-Solvay ovens at Ensley, with a daily capacity of about 1,250 tons.

The 80 Semet-Solvay ovens at the Central Furnace near Tuscaloosa were not yet in operation in 1903.

Most of the coke is made from slack coal but the entire output of some of the mines, after crushing, washing and draining, is converted into coke. With one or two exceptions, the heat and gases from the bee hive ovens are allowed to go to waste; but the Semet-Solvay ovens, of course, utilize these products.

At a valuation of $2.45 a ton the coke product of Alabama during 1903 was worth nearly $6,000,000.

THE WARRIOR COAL FIELD.

This field which lies to the north and west of the other two above named, has nearly ten times the area of the two combined, estimated at 7,800 square miles. In the usual classification the Warrior Field comprises all of the coal measures of Alabama, drained by the Warrior and Tennessee Rivers, together with those of Lookout Mountain drained by the Coosa river.

The relatively greater importance of the Warrior Field is due also to the vast amount of coal that can be economically mined within its limits, the coal seams outcropping over great areas and with very moderate angle of dip.

For convenience of description the Warrior Field has been divided into the Plateau Region and the Warrior Basin.

The *Plateau Region* includes the northeastern part of the Field, approximately from the line of the L. & N. railroad to the Georgia and Tennessee borders, together with the spurs of the great Cumberland table land on the western and northern side of the Tennessee river. The name comes from the circumstance that the uplands or mountains are portions of the original elevated table land or plateau into which the valleys

have been cut to the depth of 600 to 800 feet. The altitude of these uplands varies from 1200 to 1800 feet above tide water in the northeastern part, to 700 or 900 feet in the vicinity of the L. & N. railroad. The Coal Measures which take part in the formation of these uplands are the strata between the Black Creek Coal Seam and the base of the Coal Measures, embracing about 1800 feet thickness. This full thickness of the plateau measures, including 15 or more seams of coal, occurs along the southern limits of the Plateau region where it merges into the Basin, while near the northern edge adjoining Georgia and Tennessee, there are only about 200 feet of coal strata including one or two coal seams. It will thus be seen that the strata dip towards the southwest at a more rapid rate than does the surface of the country, and the coal measures thicken proportionally in the same direction. The coal seams in the Plateau region are very variable in thickness occurring in bulges and squeezes. Where the strata are thick enough to carry them only about four of the coal seams appear to be always present, only about six of them ever to be of workable thickness, and only two of them of workable thickness in most of their outcrops. In general these plateau coal seams are thickest and most reliable in the northeastern part of this region near the Georgia and Tennessee lines. The coal is usually good, hard, and solid, though sometimes carrying considerable pyrites. Mines have been opened on these seams at a number of places, but the want of uniformity in thickness has prevented any extended operations. In 1903 the production from this region was only about 17,500 tons. These lower seams have furnished all the coal mined in Tennessee and Georgia.

The *Warrior Basin* includes the larger, southeastern part of the field extending in general from the line of the L. & N. Railroad down to where the coal measures pass finally below the Cretaceous formations and appear no more at the surface. As has already been said, the strata dip more rapidly towards the southwestern end of the field than the surface of the country falls away, and the greatest thickness of the measures in consequence is to be found in the southwestern part of the area, in Tuscaloosa county.

The Coal Measures of this region include the strata from the Black Creek coal group to the top of the measures, about 2,-

000 feet, and they contain six groups of coal seams, which, in ascending order, are as follows: the Black Creek group with three seams; the Horse Creek group with five seams; the Pratt group with five seams; the Cobb group with three seams; the Gwin group with two seams; and the Brookwood group with five seams. The seams of a group are seldom more than 25 feet apart, while the groups themselves are usually separated by 200 to 300 feet or more of barren measures. Of the 23 seams above mentioned, 21 have in some of their outcrops a thickness of at least two feet, and may be considered workable. The thickness of the seams varies from a few inches up to 16 feet, but as usual, the thicker seams are more or less shaly. The Warrior Basin furnished in 1903 nearly 10,500,000 tons of the total product, obtained mostly from the seams of the Brookwood, Pratt, Horse Creek, and Black Creek groups, the Pratt and Horse Creek groups furnishing by far the largest proportion. The mines are in nine different counties, Jefferson county alone supplying about 6,250,000 tons, or nearly half the total output of the state. Of the 235 mines, 166 are drifts; 63 are slopes, and 6 are shafts.

Most of the coal of this basin is free burning and good both for steam and domestic purposes and for coking. From the coal of this basin about 2,621,000 tons of coke were made in 1903. As a rule the coal of the Warrior field has a jointed structure by reason of which it breaks into cubical or rhomboidal blocks, though some of it is hard and compact and devoid of this structure. Mineral charcoal is common in the coal of some of the seams, especially west of the Warrior River.

The accompanying view, Plate III, shows a section of the Blue Creek Coal seam of the Horse Creek group, at one of the mines of the Tennessee Coal & Iron Company, in the Little or Blue Creek Basin of the Warrior Basin.

THE CAHABA COAL FIELD.

This is the middle one of the three Alabama Coal Fields. Its length from northeast to southwest is 60 to 70 miles and the width of the upper part about five or six miles, but it widens out towards the southwest, and below the line of the L. & N Railroad it has a width of 12 or 15 miles; the area embraced is about 400 square miles.

Plate III—Section of Blue Creek Coal Seam, Tenn. C., I. & R. R. Company's Mine, Jefferson County.

The northwestern border of the field is made by the escarpment of Shades Mountain overlooking Shades Valley; the southeastern boundary is a fault of 10,000 feet displacement, by which the Cambrian strata are brought up to the level of the Coal Measures. Along the southern border of the field from Montevallo westward, this fault has overturned a narrow strip of the measures, including several seams of coal.

In structure this field is an unsymmetrical synclinal with its axis very close to its southeastern edge. As a consequence most of the strata of the field have a dip to the southeast almost to the edge of the field, the structure seems to be monoclinal, and the greatest thickness of measures is very close to the eastern border. The wider part of the field, to the southwest of the L. & N. Railroad, is divided by an interior faulted anticlinal which separates the Blocton Basin on the west from the Montevallo and other basins on the east. Minor warpings of the strata have broken the field up into a number of smaller basins.

As with the Warrior Field, so here, the general dip of the field as a whole is to the southwest, and at this end of it we find the greatest thickness of the measures aggregating some 5,500 feet, and holding 50 or more coal seams, half of which have in places a thickness of 2 feet and upwards.

The Maylene basin north of the Montevallo appears to have the topmost measures, and consequently the greatest thickness.

At the present time mining operations are practically confined to the wider southern end of the field beyond the line of the L. & N. railroad, the principal center of production being in the vicinity of Blocton, where at least a dozen mines are in active operation, the Thompson seam being the one mainly worked. East of the interior fault and the measures immediately adjacent to it, much mining is also done in the Montevallo and Maylene basins on the Montevallo and Maylene seams, and along the Southern Railroad also at Glen Carbon, and near Helena on other seams.

The mines of the Cahaba field furnished in 1903 1,781,078 tons of coal. This coal was mined from eight different seams and nineteen mines, eighteen of which were slopes, and one a drift.

As a general rule, the Cahaba coals are of excellent quality. Some of them are the finest steam and domestic coals in the state, and from some an excellent quality of coke is made. The

coal of the Cahaba field is in general somewhat harder and cleaner than the Warrior coal, and it is exported to Mexico and South America in large quantities.

THE COOSA COAL FIELD.

This, the smallest, least known and least productive of the coal fields of Alabama, lies to the east of the other two. Like the Cahaba field, it is long and narrow, being sixty miles in length, with an average width of less than six miles, and an area of over three hundred square miles. The southwestern end, like the southwestern end of the Cahaba field, is separated into two parts by a narrow faulted anticlinal valley. The northwestern border of the field is a high mountainous escarpment. The eastern border is made by a fault, which brings Silurian strata up to the level of the Coal Measures. The general dip of the field, as in the other two, is towards the southwest, and the field is an unsymmetrical anticlinal, with its axis close to the eastern edge. We find, therefore, the thickest measures along the eastern edge of the field, and towards its southwestern extremity. It is not easy to determine the thickness of the measures included in the Coosa field, but it is less than in either of the others. The general dip of the strata above mentioned is interrupted at intervals by minor undulations, which have broken the field up into a number of somewhat independent basins. Some seventeen or eighteen seams of coal have been identified in this field, seven or eight of which have in places a thickness of two feet and more. The thickest and most important of these seams occur near the eastern border of the field, and do not underlie very much territory. Mining operations have been carried on mainly at two points, namely, Ragland and Coal City. The output of the field for the year 1903 was 121,000 tons. The coal is remarkably pure, free from dirt and pyrite, and whilst not so hard as the Cahaba coal, is excellent for coking. Some of the earliest mining in the state was done at the two points mentioned.

Those interested will find in the following Reports, published by the Geological Survey, further details concerning the several coal fields:

On the Plateau Region of the Warrior Field; by Henry McCalley.

On the Warrior Basin, by Henry McCalley.

On the Cahaba Coal Field, by Joseph Squire; On the Coosa Coal Field, by A. M. Gibson.

THE STONE.

Limestones and Dolomites.

These rocks which are used for furnace flux and for lime burning are to be found in Alabama in sufficient quantity to satisfy every demand that will ever be made on them.

The fluxing rocks in all the furnaces of the state were exclusively limestones until a few years ago, when dolomite was found to be well adapted to the purpose, and it has since come into very general use in the Birmingham district, where it exists in very convenient proximity to the furnaces. The dolomite as a rule, is of more uniform composition and freer from silica than the limestones, that used in the Birmingham furnaces holding on an average not more than 1.5 per cent. silica, while the limestone will generally average 3 to 4 per cent. The dolomite is therefore better for the making of low silicon pig iron. The purest of the limestone beds are however purer than the best of the dolomite, but the interstratification of ledges of varying quality necessitates much careful selection in quarrying.

The use of limestone as a flux is now again on the increase because of demand for the slag for cement making.

Dolomite.—The most important horizon of the dolomite is the Knox Dolomite of the Cambrian, while the limestones belong mostly to the Trenton of the Lower Silurian and to the Mountain Limestone division of the Lower Carboniferous. All of these have been very extensively quarried to supply the furnaces.

The *Knox Dolomite* as a formation is from 2,000 to 5,000 feet in thickness, the lower part containing some beds of exceedingly pure dolomite, while in the upper part this dolomite is very much intermixed with chert.

The rock used as flux is mostly coarse grained, light gray to dark blue in color, and more or less crystalline in texture.

Dolcito quarry, near Birmingham, is one of the largest in the state, having a capacity of 2,000 tons a day. At the present time it is some 300 yards long and nearly 100 feet in depth at the deepest part. It shows a number of ledges which carry less than 1 per cent. of silica in car load lots.

About one car load a day of selected lump from these ledges is sent to the Ensley Steel Works to be used instead of magnesite in the lining of the furnaces.

The accompanying view, Plate IV, shows the condition of this quarry in 1900.

Other large quarries in the Dolomite are in the immediate vicinity of North Birmingham.

The dolomite from this formation is not used in lime burning though it would no doubt make an excellent lime, as is shown by the lime made of a crystaline dolomite at the Chewacla lime works, in Lee county, near Opelika, where the dolomite of unknown geological age is associated with metamorphic rocks.

Limestone.—The most extensively quarried limestone is that occurring in the Lower Carboniferous formation and generally known as the *Mountain Limestone.* In the northern part of the state this rock is 350 to 1,300 feet in thickness, and covers a great area. In the southeastern part of the region of their occurrence these limestones become very slaty and sandy.

The purer portions of this limestone carry from 95 to 99 per cent. carbonate of lime, but with the better quality of the rock, shales are often interstratified and in the lower part of the formation, the limestone is highly siliceous and of dark blue color.

The Mountain Limestone, as the name indicates, often occurs on mountain sides above drainage level, and therefore in position admirably situated for extensive and cheap quarrying. The principal quarries are near Blount Springs and Bangor on the L. & N. railroad, and near Trussville and Vann's on the A. G. S. railroad.

The *Trenton* or *Pelham Limestone* of the Silurian is another great limestone formation which has been much used both as flux in the furnaces and in lime burning. This limestone occurs in long narrow belts on the flanks of the Red Mountain ridges on each side of the anticlinal valleys. Sometimes it lies in the valley at the foot of the mountain, sometimes it occurs

Plate IV—Dolomite Qu

rry at Dolcito, Jefferson County.

high up on the side of the mountain and at times even up to the summit. The rock in its best quality is a compact blue limestone, often highly fossiliferous. Weathered surfaces are frequently marked with furrows called "karren felder" which resemble the furrows which one makes by drawing the outspread fingers over a soft surface of plastic clay. These marks are caused by the dissolving action of the little rills of rain water running down the exposed surface.

The best part of the rock is comprised within the uppermost 200 feet of the formation, the purest ledges carrying from 95 to 98 per cent. of carbonate of lime. With these ledges, however, are interstratified others of less desirable composition.

Some of the quarries on the sides of the mountains show clear faces of the stone 100 feet in height, and hundreds of tons can be thrown down by a single blast. These quarries have all the conveniences of situation above the crushers and railroad tracks, and are admirably located for large production at small cost. One extensive quarry is that of the Sloss-Sheffield company near Gate City.

For lime burning this rock has probably been more extensively used than any other in the state, supplying kilns at Pelham, Siluria, Hardyville, Genadarque, Longview, etc., in Shelby county for the manufacture of the long celebrated "Shelby Lime."

In this connection we may speak of other forms of limestone capable of industrial application, viz., marbles and lithographic stones.

Marbles.

The marbles of Alabama are of two kinds, crystalline or true marble, and non-crystalline.

The *crystalline* or *statuary marbles* occur mainly in a narrow valley along the *western* border of the Metamorphic rocks, extending from the northwestern part of Coosa county through Talladega into Calhoun. The outcrops have a width of about a quarter of a mile and a length of 60 miles at least.

The best as yet known are in Talladega county, and the principal quarries from which the stone has been obtained are in the vicinity of Sylacauga, and near Taylor's Mill, on Talladega Creek. At a number of places within these limits, before

the civil war, marble was quarried and worked into monuments chiefly. Since the war very little has been done in this line. The quarries were not sunk to any considerable depth (25 feet) and it is doubtful if any of them has gone below the reach of weathering.

In some places the marbles are defective from streaks of talc and a kind of slaty cleavage, but many fine blocks have been obtained and worked up.

A stone from Gantt's Quarry was presented by the Masons of Alabama to the Washington Monument Society in 1851 to be incorporated in the monument. The quality of the marble was such that it was believed by many to have come from Italy. During the present year the Italian sculptor Moretti, who has designed and modeled the Alabama iron colossus, "Vulcan," has obtained some beautiful granular marble from Talladega, which he has wrought into a number of pieces of statuary which will be on exhibition at the St. Louis Exposition.

There is now in Birmingham from Talladega a block of white marble, 30 feet in length and 3 feet wide and 2 feet thick.

In composition most of this marble is quite pure lime carbonate (97 per cent.) and it has been used as furnace flux in one of the iron furnaces.

Along the *eastern* foot of the Talladega mountain range also there are two places where a crystalline dolomite has been observed, viz. in Chilton county on the banks of the Coosa river and in Coosa county immediately opposite and up the banks of Paint Creek. The other locality is near Elder postoffice, in Clay county. Nothing has been done at either of these localities in the way of developing the stone.

Still further southeast in Lee county near Opelika there is a quarry in white crystalline granular dolomite, which has been worked for a great many years for making lime. This is the Chewacla lime works and quarry. This same deposit has been traced for a number of miles both northeast and southwest of the Chewacla quarry, and the stone has been obtained and used in lime-burning at Echols Mill, at Springvilla, etc., but at this time only the Chewacla works are in operation. This stone, while of beautiful white color and granular texture, has in some of the ledges small streaks of talc also of white color, which would seriously interfere with its use for ornamental purposes. It is probable that some of the ledges are free from this defect.

The *non-crystalline marbles* occur in most of the limestone formations of the state. Under this term we would include those compact limestones which take a good polish and which have an agreeable color and which can therefore be used for ornamental purposes. Rock of this kind has been utilized from the Cambrian formation, from the Trenton, from the Lower Carboniferous, and from two horizons in the Tertiary, viz., at the base in the Midway or Clayton division, and higher up in the St. Stephens limestone.

The Trenton and Cambrian limestones are often beautifully variegated in similar manner to the Tennessee marble. Handsome blocks of this quality have been cut and polished from near Calera, from Pratt's Ferry on the Cahaba River, and from Jones Valley between Bucksville and Bessemer.

No regular quarrying and working has been done except at Pratt's Ferry, but much beautiful stone has been obtained at that point.

The Lower Carboniferous limestones are generally of a grayish color, sometimes oolitic, sometimes packed with fossils which make very pleasing variety in the color and shade in polishing.

The Tertiary limestones, especially the St. Stephens, while usually of open porous texture, hold ledges of hard, almost crystalline rock capable of taking good polish. The colors vary from nearly white through shades of yellowish into red, and it would make a handsome decorative marble for inside work especially. This rock occurs along the banks both of the Tombigbee and the Alabama rivers, at Oven Bluff and St. Stephens, and some intermediate points on the former, and from Gainestown up to and above Marshall's Landing on the latter. It will probably soon be used in cement making and further acquaintance with its varieties, due to extensive working, will no doubt direct attention to those ledges of the formation which will make good marbles.

The dolomites of the Knox horizon are also in part of suitable quality for ornamental work. The geological map of the state will show the distribution of these rocks, which is very extensive. The spots where they have been actually cut and polished are few.

Lithographic Stone.

A bedded limestone of the Lower Carboniferous formation in Jackson county has been quarried on a very small scale, polished and engraved, and prints made therefrom, which are very satisfactory. One of these engraved stones is in the museum of the University.

Some of the dolomites of the Knox formation in the central parts of the state have also been pronounced to be fit for this purpose, but they have not been subjected to the practical test of actual use.

In the Report on the Valley Regions, Parts I and II, will be found other and fuller details concerning the calcareous rocks just described.

CHAPTER II.

CLAYS AND CEMENT.

The industries which in the near future bid fair to rival in importance that of Iron Making, are those connected with the utilization of our vast resources of clay and of cement materials, and these come appropriately next to be described.

KAOLINS, CLAYS AND SHALES.

Many accumulations of clay-like materials, are the insoluble residues left from the decomposition of other minerals and rocks, and when such clays have not been removed far from their parent rocks they are known as residual clays. Some of the purest of clays, *i. e.*, kaolins, are of this kind, resulting from the decomposition of feldspars, and on the other hand residual clays left after decomposition of limestones and of many crystalline rocks, are among the most impure of the clay kind.

Any of these residual clays, from the pure kaolins to the heterogenous mixtures left from limestones, etc., may, by the action of running water, be taken up and redeposited in secondary positions, becoming thus sedimentary clays. In this removal from one place to another, much of the contaminating material may be separated from the clayey matters, and in this way the secondary deposits may occasionally be freer from foreign admixtures than the original residual mass. But, as a rule, the opposite is the case, and the more a mass of clay has been subjected to transportation and redeposition, the more likely it is to take up and incorporate impurities of all sorts.

KAOLINS.

If we use this term to designate only the residual material from the decomposition of feldspars, the kaolins are in Ala-

bama restricted to the area of the crystalline or metamorphic rocks, embracing parts or all of Cleburne, Clay, Randolph, Lee, Macon, Tallapoosa, Elmore, Coosa, and Chilton counties. The kaolins are usually associated with veins of coarse grained granites or *pegmatites* intersecting the other rocks of this region, the kaolin being derived from the feldspars of these granites.

The northwestern part of Randolph and adjacent parts of Cleburne and Clay counties may be considered the central area of kaolin occurrence, though it is not wanting in the other parts of the region mentioned.

Up to the present time none of these deposits has been utilized in a commercial way, but from some of the Randolph county kaolin specimen sets of fine china ware were made and exhibited at the Art Institute Fair in Philadelphia, December, 1900, where they were awarded a premium.

Table 1—Composition of Kaolins.

	Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Alkalies.	Ignition.	Total.
1	Washed Kaolin, 1½ m. N. E. of Milner, Randolph County	47.75	38.00	.20	*	*	*	14.85	100.80
2	Washed Kaolin, 1½ m. S. E. of Micaville, Cleburne County	45.20	38.00	*	.22	*	*	15.90	99.32
3	Kaolin, J. B. Ross, Miller Place, Micaville, Cleburne County	46.88	39.97	.08	.30	*	.64	13.87	101.74
4	Kaolin from S. ½ S. 28, Tp. 18, R. 11 E. Senator McIndoe, Randolph County	42.41	38.33	...	...	.70	...	17.42	......

*Trace.

CLAYS.

These include materials varying in composition from that of the vein kaolins above mentioned to the most impure aggregations having a clay basis.

China Clays.—The clays used in the manufacture of porcelain and fine white earthenware, which, from absence of iron burn white or nearly white at moderate temperatures, are called china clays. Their composition varies between somewhat wide limits, some having very nearly the composition of vein kaolins, while most of them contain a much higher percentage of silica. The china clays are associated with the older formations of the state in Calhoun, Talladega, Cherokee, DeKalb, Etowah, and perhaps other counties, and with the Tuscaloosa formation of the lower Cretaceous in Marion, Colbert, Fayette, Tuscaloosa, and Bibb.

The composition of the various qualities of china clays as yet examined in the state are shown in the appended table of analyses.

Table II—Showing Composition of China Clays.

Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Alkalies.	Ignition.	Total.
1. China Clay, Eureka Mine, DeKalb Co..	47.00	38.75	.95	.70	*	*	12.94	100.38
2. J. J. Mitchell's Chalk Bluff, Marion county	47.20	37.76	*	*	*	*	14.24	99.20
3. Near Kymulga, Talladega county...	50.45	35.20	.80	.60	.62	....	12.40	100.07
4. F. Y. Anderson's, DeKalb county	53.50	34.45	.21	.30	*	.21	13.20	101.87
5. Rock Run, Cherokee county...	60.50	26.55	.30	.90	.65	2.70	7.20	99.50
6. Pegram, Colbert county	64.90	25.25	*	*	*	....	8.90	99.05
7. Briggs Frederick's, Chalk Bluff, Marion county	65.49	24.84	*	1.26	*	*	7.80	99.37
8. J. R. Hughes', Gadsden, Etowah county	67.95	20.15	1.00	1.00	*	1.87	8.00	99.97

*Trace.

Fire Clays.—These are clays which do not fuse when subjected to a high temperature, at least 2700 degrees Fahrenheit. Semi-refractory clays which cannot withstand a temperature of more than 2300 to 2400 degrees are sometimes called fire clays, and are in fact used along with other more refractory clays in the manufacture of certain classes of fire brick. The fire clays of non-plastic character are known as flint clays, and have nearly the composition of kaolinite. The only Alabama material which might be classed as a flint clay occurs very abundantly in the lower Claiborne or Buhrstone formation of the Tertiary. It is, however, a highly siliceous material carrying as much as 85 per cent. of silica, and containing a great number of the siliceous tests or shells of *radiolaria.*

The plastic fire clays are rather widely distributed, occurring in the Cambrian and Silurian formations, in the Lower Carboniferous, and most probably in the Coal Measures, though none has as yet been investigated from that horizon. The Lower Cretaceous or Tuscaloosa formation, which stretches as a belt around the southern and western edge of the older formations, is perhaps the most important in respect of its clays of all sorts. The following table will show the composition of refractory clays from a number of localities, together with their melting points. The bauxites of Cherokee county have been tested as to their refractory qualities and from these tests it appears that they may be advantageously used in connection with refractory fire clays in the making of fire brick. Several analyses and fire tests, of bauxites have been included in the table.

Manufactories of fire brick are located at Bessemer, Ashby, Brickyard, Fort Payne, etc.

Table III.—Composition of Refractory Clays.

Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Alkalies.	Ignition.	Incipient Fusion, °Fah.	Vitrification, °Fah.
1. Rock Run, Cherokee County, Cambro-Silurian	47.60	36.70	1.10	1.30	*	*	14.20	3146°	.....
2. Fire Clay, Rock Run, Cherokee County, Cambro-Silurian	34.60	45.80	.52	.....	.....	.....	20.00	†3050°	.....
3. Low Grade Bauxite, Rock Run, Cherokee Co., Cambro-Silurian	31.20	44.28	1.45	1.00	.20	.....	22.60	3146°	.....
4. Low Grade Bauxite, Cambro-Silurian	18.30	54.39	1.36	.....	.....	.....	27.60	†3150°	.....
5. Fire Clay, Peaceburg, Calhoun County, Cambro-Silurian	51.90	35.00	.99	.23	.10	.55	11.30	2300°	3150°
6. Valley Head, DeKalb County, Lower Carboniferous	82.04	12.17	*	*	.33	.60	4.33	2400°	3050°
7. Fort Payne, DeKalb County, Lower Carboniferous	66.25	22.00	1.60	*	*	.75	9.05	2300°	3050°
8. Pearce's Mill, Marion County, Cretaceous	52.95	35.10	.80	*	*	.93	11.40	3050°	3150°
9. Bibbville, Bibb County, Cretaceous	74.25	17.25	1.19	.40	*	.52	6.30	2300°	3050°
10. M. & O. R. R. cut, W. of Tuscaloosa, Tuscaloosa Co., Cretaceous	58.13	24.68	3.85	.15	.32	1.78	11.78	2200°	3050°
11. Siliceous Flint Clay, Choctaw County, Tertiary	86.30	5.12	1.60	.46	.....	.....	6.60	2300°	2500°
12. Fire Clay, Cuba, Sumter County, Tertiary	50.25	35.20	1.80	.50	.30	.45	10.30	2102°	3038°‡

*Trace. †Not affected at this temperature. ‡Above.

Pottery or Stoneware Clays.—Stoneware clays are intermediate in their nature between fire clays and pipe clays, that is too impure for the one purpose and too good for the other. In the manufacture of stone ware it is essential that the clay should burn to a dense impervious body at not too high a temperature, and the color after burning should be uniform and good, if the ware is to be unglazed or is to be coated with a transparent glaze. Clays suitable for stone ware occur in the older formations, Cambrian, Silurian, Lower Carboniferous, and in the Lower Cretaceous or Tuscaloosa. This remark applies rather to the clays which have been investigated by the Geological Survey, and it should be understood that stoneware clays occur in other formations and in other parts of the state than those from which the subjoined examples have been taken.

In the table showing the composition we have given such notes as to color and character assumed in the burning, as will assist one in arriving at a correct estimate of the properties of the clays.

Table IV—Composition of Stoneware Clays.

Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Alkalies.	Ignition.	Remarks.
1. Stoneware Clay, Blount Co., F. S. White	61.50	26.20	2.10	0.50	0.43	0.70	7.29	At 2200° Fah. burns to dense body—cream color. At 2350° vitrifies—light gray color.
2. Pottery clay, Rock Run, Cherokee Co. C. C. Davenport	57.00	17.80	5.60	2.10	1.20	6.00	9.45	At 2150° Fah. fuses to transparent glass, suitable for natural glaze.
3. Pottery clay, McLean's, Elmore County	62.60	29.98	.72	.40	.36	.65	8.60	Burns to dense, smooth, bluish white body. Vitrifies at 2150° Fah. Viscosity at 2400° Fah.
4. Pottery clay, Tuscaloosa Co., H. H. Cribbs	65.35	21.30	2.72	.60	.86	*	8.79	Burns to dense yellowish body. Vitrifies at 2200° Fah. Viscosity at 2400° Fah.
5. Pottery clay, Pegram, Colbert County, J. W. Williams	66.45	18.53	2.40	1.50	1.25	*	8.68	Burns to dense yellowish white body. Vitrifies at 2300° Fah. Viscosity at 2500° Fah.
6. Pottery clay (refractory) Fayette Co. Shirley's Mill	72.20	17.42	2.40	*	*	.56	7.52	Burns to yellowish white body. Vitrifies at 2200° Fah. Viscosity at 2400° Fah.
7. Pottery clay, Franklin Co., Thos. Rollins	67.50	19.84	6.15	.12	.10	....	7.65	Burns to reddish gray body. Vitrifies at 2100°. Viscosity at 2300° Fah.
8. Pottery clay, Marion Co. 10 m. S. W. of Hamilton	70.00	21.31	2.88	.20	*	*	6.85	Burns to grayish buff color. Vitrifies at 2150° Fah. Viscosity at 2350° Fah.
9. Stoneware clay, Fayette Co., H. Wiggins	63.27	19.68	3.52	1.30	*	1.20	9.80	Burns to dense red body. Vitrifies at 2100° Fah. Viscosity at 2300°.
10. Stoneware clay, Lamar Co., Fernbank	69.50	13.00	6.40	.25	*	*	10.10	Burns to hard dense body of deep red color. Vitrification at 2100° Fah. Viscosity at 2300°.
11. Stoneware clay, Pickens Co., Roberts' Mill	68.23	20.35	3.20	.34	*	.74	7.16	Burns to dense buff body. Vitrification at 2200° Fah. Viscosity at 2400°.
12. Pottery clay, Cuba, Sumter County	50.25	35.20	1.80	.50	.30	.45	10.30	Burns to whitish color, becoming buff at 2354° Fah. Not vitrified at 3038°.

*Trace.

Of the above analyses, Numbers 1 and 2 are from Paleozoic formations; Numbers 3 to 11, inclusive, are from the Lower Cretaceous, (Tuscaloosa), and 12 is from the Tertiary, and they have been selected from a great number to illustrate the wide distribution of clays of economic value.

Clays and Shales for Portland Cement Making.—Under the head of Cement Resources, we have given a number of analyses of clays adapted to use in cement making, and add here several others.

These clays, like the preceding, are widely distributed, as may be seen from the localities given, and they are from a great variety of geological formations.

Analyses of a few shales from the Coal Measures are also appended as being very likely to come into use in this connection, not only because of the fitness of the chemical composition, but also on account of their proximity to the Trenton and Lower Carboniferous limestones and to the mines of coal.

While the composition of the limestone which is to be used in the cement manufacture, varies in the different formations, and will in a measure determine the character of the clay which will be suitable to mix with it, yet there are certain limits within which the composition of the clay must fall in order to adapt it to the rotary kiln in the burning of the cement. Ordinarily a clay will give good results which contains as nearly as possible 60 per cent. of silica and about one-third as much, or less, of alumina and iron oxides, the smaller the proportion of iron the better. The clay should not contain more than 2 per cent. of magnesia and as little sulphur as may be. (D. Fall.)

Table V.—Composition of Shales and Clays suitable for Portland Cement making.

Locality.	Silica.	Alumina.	Ferric Oxide.	Lime.	Magnesia.	Sulphur Trioxide.	Alkalies.	Ignition.
1. Carboniferous Shale, Coaldale, Jefferson Co.	57.22	24.72	7.14	0.49	1.88	0.40	....	7.09
2. Carboniferous Shale, gray, Birmingham, Jefferson County	57.80	25.00	4.00	2.10	.80	....	1.80	7.50
3. Carboniferous Shale, yellow, same locality as No. 2..............	61.55	20.25	7.23	*	.99	....	2.25	6.19
4. Hull's Station, A. G. S. R. R., Tuscaloosa Co., Cretaceous...........	61.25	25.60	2.10	.25	.82	....	1.35	8.10
5. M. & O. R. R., 10 m. West of Tuscaloosa, Tuscaloosa County. Cretaceous	58.13	24.68	3.85	.15	.32	....	1.78	11.78
6. Blount County, F. S. White, Paleozic	61.50	26.20	2.10	.50	.43	....	.70	7.29
7. Chalk Bluff, Elmore Co., Cretaceous	60.38	20.21	6.16	.09	.72	....	1.80	10.21
8. Cribb's place, Bedford, Lamar Co., Cretaceous	60.90	18.98	7.68	*	*	....	*	13.36
9. Sand Mountain Cut, M. & O. R. R., Bibb Co., Cretaceous.......	58.50	24.95	4.65	.50	.30	....	.20	.....
10. Same locality as 9...	59.33	25.28	3.37	.80	.10	....	.65	9.50
11. Blue Cut, M. & O. R. R., 10 m. W. of Tuscaloosa. Cretaceous...	62.70	22.80	1.95	.90	.10	....	.70	10.00
12. Reform, M. & O. R.R. Pickens Co., Cretaceous	62.55	24.62	2.40	.30	.20	....	.42	10.00
13. Bluff at steamboat landing, Lower Peach Tree, Wilcox Co. Tertiary	62.10	15.14	3.20	4.90	1.60	....	2.75	9.65

*Trace.

Shales and Clays, suitable for Paving Brick, Pressed Brick, etc.—The Carboniferous shales at Coaldale, and at the Graves Mines near Birmingham, analyses of which have been given in the preceding table, have for a number of years been used in the manufacture of vitrified brick for paving, and have come extensively into the market. In the various clay deposits mentioned above there are clays in abundance, which have been used in making all the finer grades of building bricks.

It seems superfluous to speak of these in more detail, since they and the other kinds of clays are somewhat fully described in Bulletin No. 6, of the Alabama Geological Survey, prepared by Dr. H. Ries, of Cornell University.

THE CEMENT RESOURCES OF ALABAMA.

SLAG CEMENT.

No details are here given concerning the slag cement materials, since they are manufactured products. Attention is directed, however, to the circumstance that our furnaces are daily turning out vast quantities of slag suitable for making cement, and that plants for this purpose are already in active and successful operation.

PORTLAND CEMENT.

Alabama contains large supplies of limestone, chalk, clay and shale well adapted for Portland Cement manufacture, and widely distributed throughout the state. Coal and labor are abundant and cheap, transportation facilities are excellent, and many of the best limestone and chalk localities are situated on navigable rivers, giving ready access and cheap water transportation to Galveston, New Orleans, Mobile, Charleston, and other ports of the Gulf and Atlantic Coasts. This advantage of location will be immensely increased when work is begun on the Isthmian canal, for cement plants located in Alabama will be more than a thousand miles nearer to the Isthmus than their nearest possible competitors.

The limestones and shales of the northern part of the state lie so close to each other and above all, so close to the great coal mines which must supply the fuel, that the establishment of

Portland cement plants near the coal mines would give to this industry in Alabama the same advantages which the proximity of the iron ore, the coal, and the stone has given to the iron industry, and which has placed our state beyond competition.

As a Portland cement mixture, ready for burning, consists approximately of 75 per cent. lime carbonate and 25 per cent. of clayey matter, the material furnishing the lime carbonate is necessarily of more economic importance than that from which the silica and alumina are derived. In consequence, a Portland cement plant is usually located in the immediate vicinity of a suitable limestone, while the clay or shale required to complete the mixture may be brought some distance. In the present statement, therefore, the Alabama localities where cement industries may be developed will be discussed under four headings, according to the limestone available in each locality.

Disregarding limestone formations whose chemical composition renders them unsuitable for use in the manufacture of Portland cement, as well as those whose outcrops are small or badly located with regard to transportation routes, the limestones of four formations may be considered as particularly well adapted for use in cement manufacture. These are:

(1) Trenton limestone (Silurian). of Northern Alabama.

(2) Bangor limestone, (Lower Carboniferous), of Northern Alabama.

(3) Selma chalk (Cretaceous), of Middle Alabama.

(4) St. Stephens limestone, (Tertiary), of Southern Alabama.

1. *Trenton Limestone.*

Areal Distribution.—The Trenton limestone occurs in all the northeast and southwest trending valleys of Northern Alabama, outcropping usually in a narrow belt near the base of the Red Mountain ore ridges, though sometimes occurring high up on the flanks of these mountains, and in some localities underlying considerable areas of lowlands in the valleys, as at Pelham, Siluria, Longview, Calera, Shelby, Rock Springs, etc.

Chemical Composition.—As this rock is extensively quarried for lime burning and for furnace flux, many analyses are avail-

able from which it may be seen that it is a rather pure limestone, carrying normally from 1 to 5 per cent. of silica, and from .5 to 1 per cent. of iron and alumina oxides, and from 90 to 93 per cent. of carbonate of lime, with carbonate of magnesia varying from .75 to 3 per cent. It is hence a pure limestone, requiring an addition of one-fourth to one-third of its weight of clay or shale to make a suitable cement mixture.

Table I.—Average Composition of Trenton Limestones.

Locality.	Insoluble silica.	Iron and alumina.	Carbonate of lime.	Carbonate of magnesia.	Sulphuric acid.
1. Rock Springs Quarry, Etowah Co.	1.00	.30	97.00	*	*
2. Gate City Quarry, Jefferson Co. Average of five analyses	3.78	1.90	91.69	....	....
3. Longview Quarries, Shelby County. Average of three analyses	.44	.16	98.63	.92	....
4. Shelby Quarry, Shelby County. Average of three analyses	1.81	.77	96.03	1.67	....
5. Vance Quarry, Tuscaloosa County. Average of car load lots	4.68	1.22	88.85	3.52	....
6. Calcis Quarry, Shelby County. Average of six analyses	.51	.42	96.72	1.84	....

*Trace.

Physical Character.—It is a compact blue limestone of normal hardness, and would therefore require more power to crush and pulverize it than the softer rocks of the Selma Chalk and St. Stephens limestone, but it is practically free from combined water, and its use would entail no loss of heat in volatilizing moisture.

Accessibility to Clay or Shale.—In all localities of the occurrence of Trenton limestone, the shales of the Coal Measures are in close proximity, and, so far as these have been analyzed, of suitable composition for mixing with the limestone in cement making. The shales from the Graves Mines below noticed, are near the Gate City quarries, and those of the Cedar Grove mines in Tuscaloosa county are close to the limestone quarries at Vance. In both localities the shales are at coal mines in active operation.

Table II—Composition of Shales and Clays near Trenton Limestones.

Locality.	Silica.	Alumina.	Ferric oxide.	Lime.	Magnesia.	Sulph. anhydride.	Alkalies.
1. Graves Coal Mine, Jefferson Co. Gray shale	57.80	25.00	4.00	2.10	.80	....	1.80
2. Graves Coal Mine. Yellow shales	61.55	20.25	7.23	*	.98	....	2.25
3. Cedar Cove Coal Mines, Tuscaloosa Co. Shale above coal seam	58.50	16.17	11.33	1.22	1.17	.77	....
4. Woodstock, Bibb Co. Cretaceous clay	65.82	24.58	1.25	....	....	....	....

*Trace.

2. *Bangor Limestone.*

Areal Distribution.—The Bangor limestone of the Lower Carboniferous, is extensively developed in Northern Alabama, being well exposed along most of the railroads radiating from Birmingham. It is in fact so widely distributed that a detailed geological map would be required to give any adequate idea of the location of its various outcrops.

Chemical Composition.—In the vicinity of Birmingham ,at Blount Springs, at Bangor, at and near Trussville, this limestone has been extensively used as a flux in the furnaces. In consequence, numerous analyses are available, and very close estimates can be made both of its normal composition and of probable deviations from the normal. These analyses show that the Bangor limestone will usually carry 92 to 98 per cent. lime carbonate; 1 to 5 per cent. of silica; and 1 to 2 per cent. alumina and iron. Normally it does not contain over 1½ per cent. magnesium carbonate, though one exceptional analysis shows a little over 8 per cent. of that constituent.

It may, therefore, be considered as a very pure limestone, and available for use in Portland cement making; requiring the addition of one-fourth to one-third of its weight of clay or shale.

Table III.—Composition of Lower Carboniferous (Bangor) Limestone.

Locality.	Silica.	Iron and alumina.	Carbonate of lime.	Carbonate of magnesia.	Sulphur.
1. Fossick's Quarry, Rockwood, Ala. Average sample	.50	1.45	96.58	2.58	....
2. Blount Springs Quarry. Average five analyses. J. R. Harris	.95	1.01	96.25	1.27	.03
3. Vann's Quarry, near Trusville. Average of six analyses. J. R. Harris......	.81	.63	07.05	1.00	.02
4. Worthington Quarry, near Trussville. Av'ge. of 2 analyses by C. A. Meissner	2.64	2.31	87.51	4.20	....
5. Compton Quarry, Murphree's Valley. Stock house sample. Dr. W. B. Phillips	2.80	.70	94.59	....	....

Physical Character.—The Bangor limestone is a limestone of normal hardness, and cannot therefore be quarried so readily and so cheaply as the Cretaceous and Eocene limestones to be discussed later. Limestones resembling the Bangor in hardness are successfully utilized in Portland cement manufacture in New York, Ohio, Indiana, Missouri, and other states; so that this character alone need not be considered as rendering it unavailable. Its hardness is, moreover, largely counterbalanced by the fact that as quarried it will be practically free from water, and will, therefore, require the expenditure of little coal for complete drying.

Accessibility to Clay or Shale.—Thick deposits of shale of Coal Measures occur near the outcrops of the Bangor limestone in the vicinity of Birmingham. In some parts of the valley to the northeast of Birmingham excellent beds of clay at the base of the Lower Carboniferous formation, are quite extensively developed. Both the overlying shales and the underlying clays have been worked to some extent in this region, the product being used in brick and pottery manufacture. Examination of a series of analyses of these shales and clays as well as of some clays belonging to the Cretaceous formation and occurring in close proximity to some of the limestone quarries in the Tennessee Valley, shows that all of these deposits could fur-

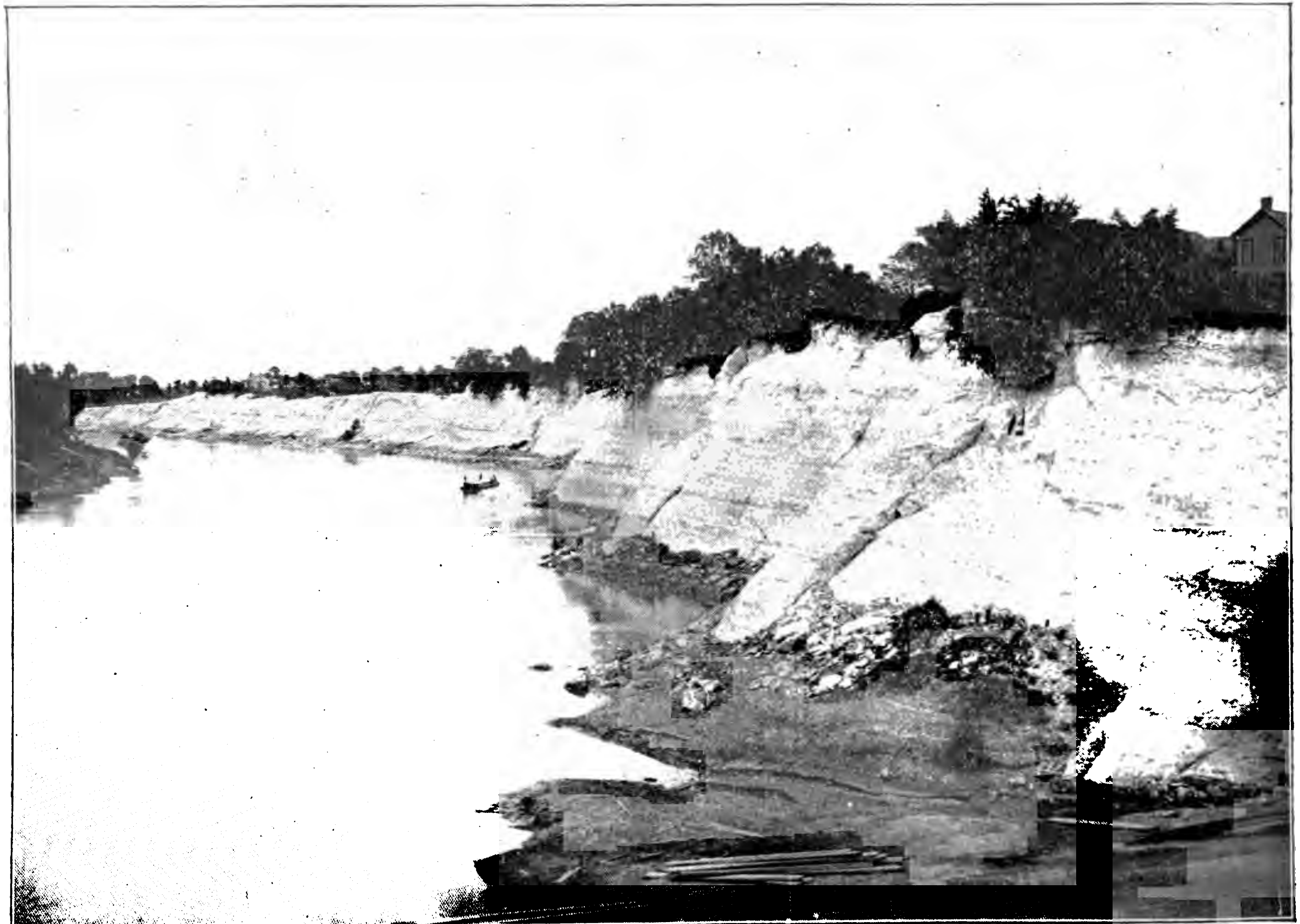

Plate V.—Bluff of Selma Chalk, left bank of Tombigbee River, Demopolis.

nish material suitable for admixture with the limestone, the underlying clays being apparently slightly better in composition than those of the shales of the Coal Measures above the limestone. The Cretaceous clays appear to be entirely suitable.

Table IV.—Composition of Clays and Shales near Lower Carboniferous Limestone.

Locality.	Silica.	Alumina.	Ferric oxide.	Lime.	Magnesia.	Sulph. anhydride.
1. Ft. Payne, DeKalb Co. Lower Carboniferous clay	66.25	22.90	1.60	....	....	....
2. Colbert Co., Pegram. Cretaceous clay	66.45	18.53	2.40	1.50	1.25	....
3. Colbert Co., Pegram. Cretaceous clay	64.90	25.25	*	*	*	....

*Trace.

The shales and clay in Table II above are also available for the Bangor limestone.

3. *The Selma Chalk (Cretaceous), of Middle Alabama.*

Areal Distribution.—The Selma Chalk or "Rotten Limestone" outcrops as an east and west trending belt, Eutaw, Selma and Montgomery, being near its northern, and Livingston, Linden, Union Springs, near its southern border. In its widest portion, towards the western part of the state, this belt is about 25 miles from north to south, but it thins to the eastward, disappearing entirely some 15 miles west of Columbus, Ga. The belt is intersected by the Alabama, Tuscaloosa, and Tombigbee rivers, and a characteristic bluff of this rock is shown in Plate V, a view of the left bank of the Tombigbee River at Demopolis.

Chemical Composition.—The Selma Chalk is about 1,000 feet in thickness, and is in general terms a very argillaceous, chalky limestone, varying considerably in the proportion of clayey matters in its different parts. In the upper and lower thirds of the formation, the proportion of clay is high and carbonate of lime will not usually exceed 60 or 65 per cent.

The rock of the middle third of the formation, which is the part best suited for cement making, will average about 70 to 85

per cent. of carbonate of lime, and 30 to 35 per cent. of silica, alumina and iron. Its magnesia content is low, well within the requirements for a Portland cement material.

The limestone in some localities shows a considerable amount of iron pyrites, however, which will cause the resulting cement to carry a relatively high percentage of sulphates.

The highly argillaceous character of the Selma Chalk has the advantage that but little additional clay will be required to make a perfect Portland cement mixture.

In the table below, in addition to the analyses of rock containing from 75 per cent. upwards of carbonate of lime, others have been added of rock carrying less than 75 per cent. of this ingredient, and which by proper mixture with the higher grades of rock might make a cement mixture without the addition of any clay.

Table V.—Composition of Selma Chalk.

Locality.	Insoluble matters.	Iron and alumina.	Carbonate of lime.	Carbonate of magnesia.	Sulph. anhydride.
1. Roberts' place, near Gainesville, Sumter County	19.10	3.70	75.57	1.24	.69
2. Jones' Bluff, Tombigbee River, at Epes, Sumter County	9.44	1.76	86.28	1.02	....
3. Bluffport, on Tombigbee River, Sumter County	11.68	1.82	85.10	1.25	....
4. McDowell's Bluff, Tombigbee River, Sumter County	6.06	1.62	90.40	1.15	....
5. Material used in Alabama Portland Cement works near Demopolis, Marengo County	12.50	2.76	80.71	1.05	1.62
6. Van Dorn Station, east of Demopolis, Marengo County	14.36	2.80	80.47	1.30	....
7. Uniontown, Perry Co., Pitt's place....	16.18	3.08	75.35	1.35	....
8. One mile S. of Uniontown, Perry Co.	12.14	2.60	83.65	1.53	....
9. R. R. cut, Milhous Station, So. R'y. Dallas County	15.30	2.44	80.10	.98	....
10. Bluff at Gainesville, Sumter Co.....	18.42	10.79	65.21	1.57	.30
11. Hatch's Bluff, Tuscaloosa River, above Demopolis. Hale County......	41.18	4.16	44.78	2.68	....
12. Selma, Dallas County. Boat landing, Alabama River	16.16	11.22	65.08	2.42	1.40
13. O. M. Cawthon, near Selma, Dallas County	28.40	3.68	64.10	2.58	.08
14. Cahaba, Dallas Co., Alabama River..	31.04	2.94	64.37	.79	....

Physical Character.—The Selma Chalk is soft, and may therefore be easily and cheaply quarried and pulverized. In this respect it is probably the most satisfactory cement material in the United States. Enough should be quarried in dry weather, however, to carry the plant entirely through rainy seasons, for the chalk takes up water easily, and the expense of removing this absorbed water would be considerable.

Accessibility to Clay.—Clay beds are adajcent to, and in some cases immediately overlying, the Selma chalk. These clays, which are probably residual in origin, are in general very suitable for use, in connection with the limestone, in making up the cement mixture. It seems probable that in no case will a plant, located on the Selma chalk, have to go more than a few hundred yards to obtain the necessary supply of clay.

Table VI.—Composition of Clays near Selma Chalk.

	Silica.	Iron and alumina.	Calcium oxide.	Magnesia oxide.	Sulphuric anhydride.
1. Residual clay over chalk rock, Demopolis, Marengo County. Used in cement works	55.64	26.25	.91	1.97	*
2. Residual clay over chalk rock, Uniontown, Perry County. Pitts place	69.57	19.04	.37	....	....
3. Residual clay over chalk rock, Uniontown, Perry County. Morgan place..	56.74	27.90	.70	1.27	.13
4. Clay on Read place, White Bluff, Dallas County, on Alabama River	56.90	27.71	.86	1.64	.09

*Trace.

Besides the residual clays above noted, and which are nearly everywhere available over the chalk, it seems entirely practicable to use mixtures in varying proportions of the purer forms of the chalk as shown in analyses of Table V, Nos. 1 to 9, with more argillaceous varieties such as those shown by analyses 10 to 14. In this way a proper cement mixture might be obtained without the use of clays, where they were difficult to obtain.

4. *The St. Stephens Limestone (Eocene), of Southern Alabama.*

Areal Distribution.—The St. Stephens limestone outcrops in a belt 10 to 15 miles wide (from north to south) in Southern Alabama. The counties of Geneva, Covington, Conecuh, Escambia, Monroe, Clarke, Washington, and Choctaw are in part within this belt.

The high bluff at St. Stephens on the Tombigbee River shown in Plate VI, illustrates well the general characters of the outcrops of this rock along the banks of the Tombigbee and Alabama Rivers.

Chemical Composition.—Most of the St. Stephens beds are slightly argillaceous limestones, less clayey than the Selma chalk; while occasional beds of pure limestone occur. Both types could be utilized in Portland cement manufacture; the purer limestones requiring the addition of more clay than would the argillaceous beds.

Table VII.—Composition of the St. Stephens Limestone.

Locality.	Insoluble matters.	Iron and alumina oxides.	Carbonate of lime.	Carbonate of magnesia.	Sulphuric anhydride.
1. Bluff at St. Stephens, Washington Co...	3.38	1.04	92.85	1.92	.13
2. Oven Bluff, Tombigbee R., Clarke Co....	6.06	1.38	89.32	2.28	.15
3. Marshall's landing, Alabama River, Monroe County	2.82	1.20	94.07	1.90	.08
4. Taliaferro's Heights, near Evergreen, Conecuh County on Murder Creek....	4.04	.96	91.31	1.83	.07
5. Near Evergreen, Conecuh County	1.26	1.72	96.09	.65	.02
6. Near Evergreen, Conecuh County	2.75	2.73	93.31	.23	.02

Physical Character.—In physical character the St. Stephens limestone varies, from a soft chalky material, like the Selma chalk, to a rather hard limestone which in some localities takes a good polish and makes a very fair quality of marble. The softer beds could be quarried and crushed as readily as could

Plate VI.—St. Stephens Bluff. Tombigbee River.

the Selma chalk; even the harder beds will not be so expensive to handle as the Bangor or Trenton limestones of Northern Alabama, or as many limestones now worked for Portland cement in the Northern states.

Accessibility to Clay.—Residual clays from the decomposition of the St. Stephens limestone are usually present over most of the beds of this rock. These clays are in general quite similar to the residual clays of the Selma chalk, as may be seen by the appended analyses.

But in most of its territory, the St. Stephens limestone is mantled by the strata of the Grand Gulf formation, which includes beds of clay of considerable thickness and extent, and of quality adapted to the purposes of cement manufacture. The analyses of some of these clays will show their chemical character. The samples taken for analysis are from beds that occur in the immediate vicinity of the limestone outcrops, and either on navigable river or railroad line.

Table VIII.—Composition of Clays near St. Stephens Limestone.

Locality.	Insoluble matters.	Iron and alumina oxides.	Carbonate of lime.	Carbonate of magnesia.	Sulphuric anhydride.
1. St. Stephens Bluff, Tombigbee River, Washington County. Residual clay over limestone	59.71	24.79	.48	....	....
2. Marshall's Landing, Alabama River, Monroe County. Residual clay over limestone	51.30	35.22	1.37	.96	.41
3. Clay of Grand Gulf Formation, Manistee Juncn., L. & N. R. R., Monroe Co.	66.60	25.86	.34	.34	.89
4. Grand Gulf clay, St. Stephens, Washington County	60.68	25.60	.48	.38	*

*Trace.

The Fuel.—The question of a cheap fuel will be an important one for the limestones of the Coastal Plain and while these rocks occur along the banks of the Tombigbee and Alabama Rivers or on railroad lines, yet the high rates of freight make it difficult to get the coal from the fields of Northern Alabama at a

price that would insure the success of a plant. This in time will correct itself, but meanwhile the beds of lignite, which are numerous and of sufficient thickness at many points contiguous to the limestone outcrops and to the navigable streams, are well worth careful testing as to their suitability for use in this manufacture. It seems probable that gas might be made from them which would replace the high grade coals, and thus start up a new industry in this section of the state.

Those interested in this subject are referred to a special Bulletin on the Cement Resources of Alabama, published by the Geological Survey, and to a chapter on the same subject published by the United States Geological Survey, in Bulletin No. 225.

NOTE.—In the preparation of this account of the Cement Resources, the writer has had many valuable notes and suggestions from Mr. Edwin C. Eckel, of the United States Geological Survey.

CHAPTER III.

MISCELLANEOUS.

In this chapter will be considered those minerals upon which minor industries are based, or which give promise of being capable of being turned to profitable account.

Gold.

The gold ores of Alabama occur in the northwestern three-fourths of the region of the Metamorphic and Igneous Rocks, mainly in Cleburne, Clay, Talladega, Coosa, Chilton, Elmore, Tallapoosa, and Randolph counties. The area included is something like 3,500 square miles. The gold deposits are not uniformly distributed through this territory, but occur in several roughly parallel belts having a general northeast southwest direction. The ore bodies in Alabama as elsewhere, are quartz veins of the bedded or segregation type, occurring usually in feebly crystalline or semi-crystalline schists, often wrongly called talcose schists, though the term *talcoid* might profitably be used in describing them. Dikes of igneous rocks, granites, and diorites especially, are very commonly observed in the immediate vicinity of the gold veins. The quartz veins are sometimes of lens shape, and of considerable size, sometimes not thicker than the hand, and are apt to be in clusters or groups, the members of which are separated by barren rocks.

At times the quartz veins are associated with mica schists and other well crystallized rocks and occasionally the slates themselves in the immediate vicinity of the veins are gold bearing. Such slates hold often a great number of small quartz lenses the fillings of small fissures or parting in the slate, due generally to movements caused by the intrusion of igneous rocks. In many places the slates with numerous small quartz veins are highly graphitic, and in one locality at least, in Clay county, the gold bearing graphitic slate contains well defined

and determinable Carboniferous fossils (*lepidostrobus.*)

The gold ores run in value from a mere trace of gold to $500 a ton, but the richest ores are thin. Where the ore body consists of thin lenses in gold bearing slates the values seldom run higher than $2.00 a ton.

Above the water level these ores are all free milling, porous, friable and usually iron stained, at times showing free gold to the eye.

Below water level are the sulphurets in Alabama as elsewhere.

The quartz veins vary in thickness from a few inches to 50 feet, while the ore bodies consisting of thin lenses imbedded in the impregnated slates are sometimes several hundred feet thick. All these ore bodies maintain their values with the depth so far as they have been worked.

In addition to the above, there are a few placer deposits of much importance, and decayed rock, *saprolite,* from which gold may be obtained by merely washing.

Perhaps the most prominent and persistent of the ore leads is that known as the Devil's Back Bone, crossing Tallapoosa county near its northwestern border. In this the quartz veins are from 6 to 50 feet in thickness, and in the immediate vicinity of this ridge are several large ore bodies consisting of quartz lenses in impregnated highly graphitic slates without any well defined wall. The Back Bone is the most southeasterly of the gold belts and is probably the richest.

Only one of the belts of fully crystalline rocks, viz., the most northwesterly, carries any gold deposits of consequence, so far as is yet known.

Mining operations of greater or less magnitude have been conducted in more than 100 localities in the following counties: Tallapoosa, Cleburne, Randolph, Clay, Talladega, Coosa, Chilton, and Elmore.

In Tallapoosa county there are over 30 of these mines, the most important being in the Silver Hill, Goldville, Hog Mountain, and Eagle Creek districts.

Cleburne county has nearly thirty gold mines, the most important being in the Arbacoochee, Chulafinnee, Kemp's Creek, Turkey Heaven, and Kemp Mountain districts.

In Randolph county there are more than 20, mainly in the Goldberg, Pinetucky, and Wedowee districts. Clay county has half a dozen, all in the Idaho district. Talladega has several in

the vicinity of Waldo. Coosa has several in the vicinity of Rockford, and about Parson's Mines. In Chilton county the mining has been done on Blue Creek and Rock Creek, and in Elmore only on Peru Branch.

To the series of semi-crystalline slates, which are demonstrably metamorphosed sediments, we have in Alabama given the name of Talladega slates, and they correspond in appearance and geographical position to the Ocoee of Dr. Safford in Tennessee. These have very generally been deemed older than the Cambrian, notwithstanding strong suspicion, lacking convincing evidence, that they were metamorphosed Paleozoic strata. The finding of Carboniferous fossils in one of these belts, eight or ten miles from its western border, has made it certain that some of the so-called Talladega slates are of Paleozoic age, and probable that all of them are.

More than two-thirds of the gold workings of the state are in the Talladega slates, of which there are four separate belts of unequal width, the two being farthest to the northwest being the largest, and perhaps least important. They run together near the Georgia line. The other two belts are narrower and shorter, but at the same time more important. They are the Silver Hill and Goldville belts. To the former belong the Silver Hill, Mass, Garrett, Long Branch, Blue Hill, Farrar, Gregory Hill, Nicholls, Gold Hill, Bonner-Terrell, Eagle Creek, and other mines less well known.

The Goldville belt carries the numerous mines about Goldville, Goldberg, Hog Mountain, and Turkey Heaven, and those about Wedowee.

The Talladega or Terrapin Mountain belt carries the Parsons and Kemp Creek mines near the eastern border and the Riddle's Mill, Story, Woodward, and other mines near the western border. The mines and placers of Arbacoochee and Chulafinnee are also near the southeastern edge of this belt. Most of the mines alluded to above are mere surface diggings and shallow shafts, many of them put down prior to the great California gold excitement in 1849. The placers of Arbacoochee and Chulafinnee, and Long Branch are the most important, and work has been going on in them continuously for the past 60 years, since they always yield some returns for the labor expended on them. Very fair nuggets are obtained from Arbacoochee every year, by sluicing and panning.

Mining on the quartz veins has been carried on in a very unscientific way, and hardly ever beyond the water level. Until the past year or two no plant has been in operation for working the sulphurets. One establishment of the kind using the cyanide process is at Hog Mountain, and is meeting with success.

Most of the early mining of quartz veins was done years ago in the Goldville district and a line of old pits and shafts may still be seen along a distance of 12 miles or more. Extensive workings were also in the old time carried on about Silver Hill. Pinetucky also was one of the early mines, and it has been in continuous operation to the present time. The Pinetucky shaft is about 100 feet deep.

Gold mining in Alabama has not been as yet one of the paying industries, a fact due as we believe mainly to the insufficient capital and inadequate methods and appliances in use. The experiment at Hog Mountain will, therefore, be watched with interest.

Recently at Kemp Creek postoffice, in Cleburne county, extensive preparations have been made for the hydraulic working on a large scale of some very promising placer deposits. Water is brought a distance of four miles by ditch and flume, and the successful outcome of this enterprise will no doubt lead to the establishment of similar plants in other places.

In conclusion, we may say that the gold fields of Alabama offer inducements to capitalists, since there are very extensive deposits of ore, low grade, it is true, but of such extent and so easily and cheaply mined and milled, that there seems to be little doubt of the result if the working be done on sufficiently large scale and with the most improved methods and those best adapted to the character of the ores.

In Bulletins 3 and 5 of the Geological Survey will be found more detailed information regarding the gold region, and the material is now nearly all in hand for a final report on the subject.

Copper Ore and Pyrite.

Pyrite.—Along the eastern base of the range of mountains known as the Talladega Mountain, there is a belt of greenish rock, resulting from the alteration of an igenous rock, and to this we have given the name Hillabee Schist. Its outcrops have

been followed from Chilton county west of the Coosa river, northeastward through Coosa, Clay, and Cleburne counties to the Georgia state line. At intervals along this entire distance there are occurrences of pyrite in the form of crystals disseminated throug the mass of rock; and in beds more or less compact of crystalline pyrite. From near Dean postoffice, in Clay county, northeastward for several miles, the bed of pyrite appears at its best, being several feet in thickness and quite free from impurities.

This bed was first worked for copper, of which it holds a small percentage, and at the Old Montgomery Copper Works, there was considerable activity during the war between the states in manufacturing blue stone and perhaps other copper salts. The remains of the furnaces and other buildings are still to be seen.

Recently the Alabama Pyrites Company has begun work on this vein which averages six feet in thickness, and extends along the outcrop about one and a half miles. The analyses show an average of 42 per cent. of sulphur.

At present the workings go down about 450 feet, and the daily capacity is 150 tons. A railroad has been completed from Talladega to Pyriton, the station at the mines.

In the southeastern part of Clay county near Hatchet Creek postoffice, and at the old McGhee copper mines, there are other occurrences of the pyrite, and at the first named locality considerable work has been done in raising and shipping pyrite. These localities are not yet on a railroad line, and the hauling of the pyrites in a wagon over the mountain can hardly be done without loss.

Copper Ore.—As has been intimated above, the pyrite of the Hillabee Schist contains a small percentage of copper as a rule, but the amount seems hardly to be great enough to make it a copper ore. Near the southern border of Cleburne county at Stone Hill is the copper mine known originally as Wood's copper mine. A mile or two northeast of this there is another mine known as the Smith copper mine. The discovery of copper here was made about 1870, and a great deal of work was done during 1874-5 and 6. The main body of the ore consists of chalco-pyrrhotite and chalco-pyrite, along with a good deal of pyrite containing very little copper.

As is the case elsewhere, the first mining here was in the rich decomposition products of the weathered parts of the vein and

for several years these ores were hauled in wagons to Carrollton, Ga., and shipped thence to Baltimore for smelting. With the partial exhaustion of these surface ores smelters were erected at the mines, and from 1876 to 1879 the shipments from the mine were in the shape of ingots of copper. From 1879 to 1896 work was suspended; but in the last named year a new company was organized, "The Copper Hill Mining Company," the old mines were pumped out, a new house was erected over the slope, new machinery put in, and the mining was resumed, and a large amount of ore was brought out and stored around the opening, where most of it still remains, for no smelters were erected, and for want of railroad facilities the ore could not be profitably shipped. The new workings showed the ore body at a depth of 80 feet and below to be some 24 feet thick between walls of igneous rock of the general nature of diorite. Analyses show that the ore is richest near the two walls and that some ten feet of the ore will average 7 per cent. of copper, while the entire ore body will average probably 3 per cent.

Comparatively little mining has been carried on at the Smith mine.

Graphite.

This substance is very generally distributed among the metamorphic or crystalline rocks, and it occurs in two modes. In the feebly crystalline schists or slates which we have called the Talladega, and which in part, at least are paleozoic sediments, of as late age as the Coal Measures, the graphite is very often found as a sort of black graphitic clay free from grit and is frequently used as a lubricant. In this condition the graphite is very difficult to separate from the other matters with which it is mixed. Examples of this mode of occurrence are to be seen near Millerville, in Clay county, and about Blue Hill and Gregory Hill, in Tallapoosa.

In the mica schists and other fully crystalline rocks of this region the graphite is present in the form of thin flakes, or *lamellae,* and is comparatively easy to separate from the enclosing rock. This variety of graphite has been worked at several points in Clay, Coosa, and Chilton counties.

Some of the graphitic schists hold as much as 20 per cent. of graphite, but the average content is less. The belt of graphitic

rocks extends from Chilton county northeastward into Georgia.

In Tallapoosa county a mile below Tallassee there is a third mode of occurrence, or perhaps a modification of the second above described. Here a belt of garnetiferous schist crosses the river in an outcrop of about 100 yards width. In this schist the graphite is found in lenses or flakes which sometimes attain a diameter of two inches. As the rock disintegrates the graphite lenses weather out and are scattered loose over the surface. The same belt or a similar one is to be seen where it crosses Wolf Creek in the northern portion of Macon county.

Mica.

While mica has not been sent from Alabama to the market in anything more than experimental way, yet there is much reason for thinking that a good merchantable article can be obtained at a number of points in Chilton, Coosa, Clay, and Randolph counties. In a belt of mica schists extending through these counties, there are frequent veins of a coarse grained granite or *pegmatite,* in which the constituent minerals, quartz, feldspar, and mica, are segregated in large masses. The feldspar is very generally weathered into kaolin, and it is from these occurrences that we get all the true or vein kaolin. The mica in its turn is present in the form generally of large rough masses or boulders, from which it may be split out in sheets of varying size. In all this belt there are ancient pits or mines in which trees are now growing with diameter of 18 inches.

Around the mouths of these old diggings are great piles of broken-up refuse mica, apparently showing that a large amount of the mineral had been taken from them. In North Carolina, and probably elsewhere, the old mines of this kind have often proven to be the best places for obtaining good mica in modern times, and this fact may serve as a hint to those who contemplate mica mining in this state.

Most work in getting mica has probably been done near Micaville, in Cleburne county, and at the Pinetucky mine, in Randolph. Many tons of mica, some of it in large sheets six to ten inches in size, have been gotten up and stored away in a house, which was destroyed by fire and the mica injured, so that it was never sent to market. None of the localities is near

a railroad. A little testing, it can hardly be called mining, has also been done in several places in Clay county, and also in Coosa and Chilton.

Corundum, Asbestos and Soapstone.

These minerals are very commonly associated together and with dikes of basic igneous rocks. The main *corundum* localities are in Tallapoosa county, near Easton postoffice, two or three miles northwest of Dudleyville; and near the river, several miles south of Alexander City. In Coosa county many fine crystals have been obtained from the vicinity of Hanover. While the neighboring rocks in all these localities are *peridotites,* the masses of corundum are mostly found loose in the soil. Very little has been done at any of the localities mentioned towards actual mining, though a fiew shallow pits have been sunk, in some of which the corundum was obtained in small quantity. Dr. Lucas some years ago collected and shipped from Tallapoosa county such fragments and masses of corundum as were to be obtained from surface occurrences and shallow pits.

Asbestos is not uncommon in all the regions which show corundum, but it has not yet been found in quantity or of quality which would make it of commercial value.

Soapstone appears to be much more widely distributed than the other two associated minerals, and it is found in nearly if not all the counties of the metamorphic region. One common occurrence of it in Tallapoosa, Chambers, and Randolph counties particularly, is as a greenish schistose rock, consisting of a felt or mesh of actinolite crystals and soapstone, evidently the result of the alteration of some other rock of igneous origin. This kind of soapstone as it is called, is frequently studded with garnets sometimes half an inch or more in diameter. The rock is split out or sawed out into thin slabs which are used as headstones, hearthstones, and the like. The garnet bearing variety is mottled in a not unpleasing manner with these crystals. Another kind of soapstone is of a grayish brown color and is free from garnets, and has been used in the past by the Indians or former inhabitants of the state in the construction of utensils of various kinds, such as bowls, pots, jars, etc. Fragments of

this kind of pottery are to be seen scattered over the fields in dozens of places. A very perfect large bowl of soapstone was dredged out of the Tombigbee river a few miles below Demopolis by Mr. Eli Abbott, and is now in the cabinet of the University of Alabama. On Coon Creek, near the Tallapoosa river, in the county of the same name, there is an old quarry of this rock from which the Indians manufactured their utensils by shaping them out still attached to the parent rock, and when finished, splitting them off. Circular markings on the face of the soapstone mass show still where these finished products were broken away from the solid rock. Almost as a matter of course, this locality is associated with a tradition of an Indian silver mine.

Slabs of soapstone have been used from Chambers county for lining the lime kilns at Chewacla, for the facing of bake-ovens, and for the furnaces used for the concentration of copper ore at Wood's copper mine, the material for the last named use being obtained from the vicinity of the mines.

Lead Ore.

The only occurrence of galena of any consequence thus far known in Alabama, is in the Trenton limestone about five miles west of Jacksonville, in Calhoun county, where much work was done by the Confederate government during the Civil war. Traces of the old quarries are still to be seen, and fairly good specimens of the ore may be picked up around them. With the present perfected machines for concentrating ores it would seem that this deposit might yet be profitably worked, if only the quantity of the ore were sufficient to justify the erection of suitable plant. This can be ascertained only by the expenditure of much money. Very much of the lead ore of Southeastern Missouri is no richer than some which can be obtained from the Calhoun county mines. The subject is well worth testing.

Some small veins with galena have also been observed in the Knox Dolomite.

Loose pieces of pure galena may be found on the surface over the entire state, in localities where it could not possibly be in place. The fact that similar occurrences are noted in all the other states adjacent, has led to the inference that these loose specimens have been dropped by Indians and others who have

brought them from Missouri or other lead-producing states. There is not a county in Alabama where there is not a tradition of a "lead mine," said to have been worked by the Indians or early settlers, and the details of these traditions are infinitely varied.

Mineral Paints.

These are mainly the iron ores, the red, brown, and yellow ochres, and barite.

Ochres.—In the soft leached ore beds of the Chilton or Red Mountain formation, there are deposits of soft ore of greasy feel, free from grit, which makes a strong and most durable red paint, extensively used in the Birmingham Paint Works, and shipped from Attalla to Chattanooga to the extent of about 2,000 tons a year.

Some of the argillaceous shales of the limonite banks yield good yellow and red ochres; a fine red ochre of this kind occurring a few miles northeast of Talladega.

In the great clay formation of the state, viz., the Tuscaloosa of the Lower Cretaceous, are numerous deposits of both yellow and red ochres. Some of the yellow ochres have been mined and marketed from Autauga and Elmore counties, and a fine red ochre deposit of the same formation is known near Pearce's Mill, in Marion county. It must be borne in mind, however, that the above mentioned are only a few typical occurrences of these materials, selected out of hundreds that might be mentioned.

Overlying the St. Stephens limestone of the Tertiary, beds of good yellow ochre have been tested in Clarke county, and in the Grand Gulf territory of South Alabama also fine yellow ochre occurs in Barbour and other counties.

Barite.—The usual mode of occurrence of barite or heavy spar, is in boulders or irregular masses imbedded in the residual clays derived from the Trenton limestone, and in loose pieces on the surface. The most important localities are near Tampa, in Calhoun county, near Greensport in St. Clair, near Maguire Shoals on Little Cahaba River, at the "Sinks" on Six Mile Creek, and near Pratt's Ferry in Bibb; in all cases near the contact of the Trenton limestone with the Knox Dolomite.

The Alabama barite is of white, grayish and bluish colors, sometimes stained with iron on the surfaces. In the localities mentioned the barite is very pure and white; but it has not as yet, so far as known, been put upon the market from Alabama.

Tripoli or Polishing Powder.

Tripoli proper, the infusorial or diatomaceous earth or "fossil flour" of organic origin, occurs abundantly in many localities in the lower part of the state, e. g., in the recent swamp deposits near Mobile; in the Second Bottom deposits of the Alabama River at Montgomery; in the Buhrstone and Clayton formations of the Tertiary; the first two being of fresh water origin, while the Tertiary beds, containing marine diatoms and radiolaria, are of marine origin. In view of the fact that this material finds extended use in the covering of steam pipes, etc., it would be well worth while to investigate some of the occurrences more closely. Many details are given in the Report on the Costal Plain of Alabama.

Polishing powder of very different origin occurs in many localities in Northern Alabama. This is the result of the thorough leaching of the cherty limestones and dolomites of the Knox Dolomite of the Silurian, and of the Fort Payne division of the Lower Carboniferous. It is known as "rotten stone," and is a porous rock of finely divided siliceous matter. To fit it for use as a polishing powder it must be crushed, ground and bolted. The largest deposits are in Talladega and Calhoun and Lauderdale counties.

Some shipments have been made from the first named.

Copperas, Alum, and Epsom Salts.

These mineral salts occur in protected or sheltered places where the rocks contain iron pyrites, the weathering of which furnishes the sulphuric acid, and the country rock the iron, alumina, and magnesia. Such occurrences are most numerous in connection with the strata of the Devonian and Carboniferous formations, and are common in the open caves under overhanging rock ledges, known as "rock houses."

In the dark colored sandy clays of the Claiborne and next

underlying Tertiary formations, there are pyritous earths which have been put to commercial use in Choctaw, Washington, Clarke, Escambia, and other counties by leaching out the sulphates of iron and alumina and putting them on the market as "mineral extract," "acid iron earth," etc.

At Greenville, in Butler county, a strong solution of these acid sulphates is obtained from a shallow well, and is well known over the state as a medicinal agent.

Nitre.

The limestone caves of the northern part of the state contain large quantities of nitre, which during the civil war was obtained from this source for the manufacture of gunpowder. The marks of the picks then used are still to be seen plainly at some of the localities.

Although an organic substance, the bat guano, so abundant in many of the caves referred to, may be mentioned in this connection. This fertilizer contains 25 per cent. of organic matter, 6 per cent. of nitrogen, mainly in the form of uric acid, and from 1 to 3 per cent. of phosphoric acid, 1 to 3 per cent. of potash, and .6 per cent. of ammonia.

Phosphates.

Silurian Formation.—The phosphates of the Mount Pleasant, Tenn., district extend down into Alabama for two or three miles along Elk River and its western tributaries, Sugar Creek and Little Shoal Creek, into Limestone county. They also show along the state line for several miles to the east of Elk river, extending in places a quarter of a mile or more into Alabama. The geological horizon is probably Trenton, as in Tennessee. The phosphatic rocks do not outcrop over much area since they are usually in comparatively narrow valleys far below the general level of the country, but they underlie some large level tracts and second bottoms of the river and creeks, and are seen also covering hillsides. Exposures of more than 100 acres of these rocks occur along the line of the L. & N. railroad about a mile south of the state line.

There are two varieties to be distinguished, a friable, dark colored, porous, calcareous sandstone, and a light gray, friable, siliceous limestone. The former, derived from a siliceous dark blue limestone, weathering into flags from the fraction of an inch up to eighteen inches in thickness, occupies the lower 6 or 8 feet of the strata. The gray or upper phosphates are from 10 to 25 feet aggregate thickness, though it is not probable that all this thickness of strata is highly phosphatic at any one place. These are derived from a light bluish gray limestone that is often crystalline and that weathers into scales and flags from a fraction of an inch to two or three inches in thickness.

None of these phosphates, so far as they have yet been investigated, comes up to the grade of the Mount Pleasant rock; 75 per cent. of bone phosphate, though it is quite possible that future careful prospecting will discover them in Alabama. Small quantities of the rock have been mined about a mile west of Veto, on the L. & N. railroad.

Some 19 well weathered samples from this part of Alabama have been subjected to analysis with the result that 5 contained from 60 to 70 per cent. of bone phosphate; the others varied from 20 to 50 per cent. with one exception, and this contained less than 13 per cent.

The formations of the Coastal Plain at several horizons, hold beds of phosphatic materials which might well be utilized upon our soils.

Cretaceous Formation.—At the base of the Selma Chalk or Rotten Limestone division of this formation, there is a bed of phosphatic green sand in which occur irregular concretions and nodules of phosphate of lime.

In the disintegration of this bed the nodules of phosphate are left in considerable quantity scattered over the surface and represent in the aggregate, a very great quantity of the material, since the bed extends nearly across the state near or through Eutaw, Greensboro, Marion, Hamburg, Prattville, and Wetumpka. In no place, however, have they been found in sufficient quantity for profitable working.

On the other hand, the phosphatic green sands of this belt and of that next to be mentioned, are of nearly identical quality with the marls of New Jersey, which have been used with such

signal benefit upon the soils of that state, and there can be no doubt but that the application of these marls to the soils of Alabama, where such application can be effected without too great cost, would bring about a similar improvement with us.

At the summit of the Selma chalk occurs another bed of phosphatic green sand, with large percentage of carbonate of lime, which outcrops at least half across the state along the southern border of the Chalk, passing near Livingston, Coatopa, Linden, and other points eastward.

A few field tests have been made with both these marls and with most decided good results. We can, however, never expect their use to become general till the railroads are ready to transport them to points within the state at minimum rates.

Tertiary Formation.—Phosphatic nodules are known to occur in several of the divisions of the Tertiary, but in none as yet in quantity to make them of commercial importance. Shell marls, however, are abundant, and of easy access at many points in this region, and have been locally utilized.

Building Stones.

Limestones.—The best of these for building purposes are to be found in the Lower Carboniferous and Trenton formations, and quarries have been opened in Marshall, Colbert, Franklin, Bibb, Shelby, Jefferson, St. Clair, Talladega, Calhoun, DeKalb, and Etowah counties.

The best known are the quarries of T. L. Fossick & Co., at Rockwood, in Franklin county. The equipment at these quarries is very complete and extensive. The stone is from the Lower Carboniferous formation and it has been very largely used in the construction of the locks on the Tennessee River. The LaGarde Lime & Stone Company, at Anniston, have also an extensive plant, using the Trenton limestone, and there are several other quarries of less importance. The Trenton limestone has been used in the construction of the locks at Greensport, and the other sites on the Coosa river.

In the Tertiary formation of South Alabama some of the materials of the Lower Claiborne formation, especially an aluminous sandstone, have been utilized as rough building stones at many points. The St. Stephens limestone also is still more extensively used. This formation holds some beds many feet in

thickness, which are called "Chimney rock," from one of the principal uses made of it. This is a soft, somewhat chalky white rock, almost pure carbonate of lime, which is quarried by cross-cut saw, and shaped with saw, hatchet and plane. The principal use to which the blocks are put is the construction of chimneys and fire-places, for which, notwithstanding its composition, it is most admirably adapted, fire-places which have been in use for fifty years being still in a perfect state of preservation. In the region of its occurrence all across the state and also in the adjoining states, nearly all the chimneys and pillars to the houses are constructed of this rock.

Sandstones.—The sandstones of the Coal Measures, the Lower Carboniferous (Hartselle), and the Cambrian (Weisner), have all been used in building, and are well adapted to the purpose. In the Coal Measures quarries have been worked at Jasper and Cullman, and at Tuscaloosa. The locks on the Warrior River at the last named place are constructed of rock obtained from the bed and banks of the river. The Hartselle sandstone is quarried near Cherokee, Colbert county, and the stone has been used in the construction of the locks at the Colbert Shoals on the Tennessee River. The Weisner sandstone has furnished the material for many of the handsome buildings around Anniston.

Granites and Other Igneous Rocks.—While these rocks have not been much quarried in Alabama, they occur in great quantities and in position favorable for quarrying at many points in Lee, Tallapoosa, Chambers, Randolph, Elmore, Chilton, Coosa, Cleburne, and Clay counties. The granites outcrop in "flat rocks," which are low, dome-like masses of naked rock, sometimes 200 acres or more in extent. The largest of these flat rock areas are near Almond postoffice, in Randolph; near Blake's Ferry, and near Rock Mills, and Wedowee, in the same county; also near Milltown, in Chambers; southwest of Roxana, and along Sougahatchee Creek, in Lee. Smaller outcrops are to be found in all the other counties named. With the massive granites are associated the gneisses; both are most excellent building stones, and they are also suitable for monuments. The factories, dams, and bridge piers at Tallassee and vicinity have been constructed of the gneissoid granite, which makes the bed and banks of the Tallapoosa River there. Some use has been made of the granites about Wedowee in Randolph, at

Rockford and other places in Coosa, and rough stone has been used in the construction of the culverts and bridge foundations, etc. of the Central of Georgia Railroad in most of the counties of the metamorphic region traversed by it.

Paving and Curb Stones.—The flaggy sandstones of the Coal Measures and of the Red Mountain formation are very well adapted to these uses, and they can be gotten out in almost any desirable size. In some places these slabs are so uniform and numerous that they have received the name "plank rocks." The flags from the Red Mountain may be seen in the sidewalks and curbs of Birmingham.

Paving blocks are made from the hard flags of the siliceous limestones of the Tennessee Valley and shipped to Memphis.

Slates.

While in many localities in Shelby, Talladega, Calhoun, Cleburne, Clay, Coosa, and Chilton counties, there are great beds of slate which from their surface outcrops appear to be sufficiently promising, yet so far as we have information, they have been put to actual use only during the Civil War and for covering the Confederate arsenal building in Selma.

The slates mentioned belong to several geological formations, viz., The Talladega or Ocoee; the Weisner; and the Montevallo Shales of the Cambrian, and the upper Trenton of the Silurian.

Of these the best are perhaps the slates of the Weisner, occurring in the southwestern part of Talladega county; those of the Montevallo group in Chilton county; on Buxahatchee and Clear Creeks; and those of the Trenton in the "Dark Corner" northeast of Anniston in Calhoun.

Quarries have been started in several localities, but have been carried to no greater depth than 20 to 25 feet, not below the reach of weathering, so that adequate tests have not yet been made.

Sands.

Building sands are obtained from loose beds overlying the formations from which they have been derived; from the drifted sands along water courses; from the stratified sands of some of the newer formations, and from the harder sand-

stones of the older formations. The best of these sands which have yet come into use are obtained by crushing the friable sandstones of the older formations, especially of the Lower Carboniferous (Oxmoor) division. The material for the glass works at Gate City, analyzing 99 per cent silica—is from this source, the rock being almost at the door of the works.

Sandstones of the Coal Measures and of the Weisner formation are also in places suitable, and in the Tuscaloosa division of the Lower Cretaceous, we also have an unlimited source of sands of every grade.

In the upper of the Cretaceous divisions, viz., the Ripley, there are numerous beds of excellent sands, some quite suitable for glass making e. g. from the vicinity of Linden in Marengo county.

So also in the Tertiary formation we find numerous beds of fine sands, such as occur for instance in the vicinity of Gaston in Sumter county, and further south, in the territory covered by the Grand Gulf formation, are extensive beds of all grades, in Washington, Mobile, Baldwin, Escambia, Covington, Geneva, Dale, Henry, Houston, etc. Travellers in that section do not need to be reminded of the prevalence of sand there. The Lafayette formation lastly, which mantles the entire coastal Plain is prevalently a sand and pebble formation; the sands being as a rule, ferruginous, but in many places quite suitable for building purposes.

Road and Ballast Materials.

The materials used in road making in Alabama are chert, quartz pebbles, and limestone, including dolomite.

The chert has probably been used more extensively than either of the others. It occurs in the Lower Carboniferous formation and in the Knox Dolomite of the Silurian. In the former it is generally in more or less regular beds or sheets, in the latter rather in the form of concretionary masses. The chert from both these sources has found extended use in several counties especially Jefferson, Calhoun, Talladega. That from the Lower Carboniferous formation contains a good proportion of carbonate of lime, and shows a tendency to harden on the surface, thus making an ideal road material. Extensive quarries are near Birmingham, Leeds, Anniston, Jacksonville, and other cities.

The rounded, waterworn *quartz pebbles* are abundant in the Lafayette formation, which is a mantle of sands and pebble covering more or less completely all the central and lower parts of the state. Usually the pebbles are imbedded in a red sandy clay which acts as a cement holding them in place and forming a road surface, scarcely if at all inferior to that made by the chert. In nearly every county of the state from Tuscaloosa to the Gulf, these clay pebble beds of suitable character occur, and there is no reason why any of these counties should lack good roads.

Broken limestone and dolomite, are the most common material in some of the counties of the Tennessee valley, and in parts of the Coosa valley, and the widely distributed limestones of the Lower Carboniferous and Silurian formations of the northern part of the state furnish an inexhaustible supply.

For *ballast,* all the above mentioned road materials have been utilized, and in addition to these broken up sandstones and furnace slags.

Millstones, Grindstones and Whetstnoes.

The conglomerates of several formations of the state, especially of the Weisner Quartzite, the Coal Measures and the Lafayette are capable of yielding good millstones, and locally they have been so used, and in the early days some of them had well established reputations.

For grindstones the sandstones of the Cambrian and of the Red Mountain and Coal Measures formations, have been found suitable, and certain thin laminated sandy shales of the Coal Measuers have served for whetstones of very good quality.

Asphaltum, Maltha, Petroleum, and Natural Gas.

The asphaltum and maltha here referred to are the solid and semi-solid products resulting from the desiccation of the fluid petroleums.

These and petroleum are most common in the Lower Carboniferous rocks of Russellville and Moulton valleys and of the southern slopes of the Little Mountain of the Tennessee valley region. They occur in the highly fossiliferous crinoidal limestones and the course-grained sandstones of the formation,

which are often saturated with them to the extent that they ignite when thrown into the fire. On the surfaces of these rocks the petroleum may often be seen in yellow drops, but generally these surfaces are black from the maltha or "tar," which on sufficient exposure hardens and oxidizes into asphaltum. Several car loads of the black bituminous sandstone from the top of the Little Mountain south of Leighton, were shipped to Memphis and the tar or asphalt there extracted. These substances were also extracted from the crinoidal limestones by boiling, and several barrels of the tarry matters were scooped up out of a drift.

These tar springs have been known for many years and they were formerly places of resort by the afflicted who drank the tarry water or took pills of the maltha.

Petroleum can be obtained from the same bituminous sandstones and limestones, and also from the Black Shale of the Devonian formation, which is usually sufficiently saturated with bituminous matter to burn or ignite when thrown into the fire.

Natural gas is quite common in many parts of the state, occurring as a rule along with salt water, sometimes with small quantities of petroleum accompanying, oftener without it.

Probably the most promising of the borings for petroleum are those put down in the Tennessee Valley region. The Goyer well No. 1 in the Moulton Valley, is said to have had at one time a capacity of 20,000 cubic feet of gas and 25 barrels of oil a day; the oil was of dark green color with a not unpleasant odor. This well was bored to a depth of 2,120 feet.

For some reason the oil flow was lost, and never recovered in paying quantity. Many other deep wells have been bored in different parts of the state, as well as in the Tennessee Valley region, but without success, so far as petroleum in commercial quantity is concerned.

Many of these borings have been made in the Southern part of the state, especially in Clarke, Washington, and Mobile counties, where there are so many salt wells and salt seeps. Salt water and natural gas in considerable quantity have been obtained from many of these wells, but as yet no petroleum in commercial quantity. At Cullom Springs in Choctaw county near Bladon, a deep well bored about 1886 was probably the first among the recent borings to show considerable amount of natural gas, but many of the old borings in the salt region

made during and before the Civil War, yielded along with the brine, large quantities of this gas. In places the gas and salt water rise to the surface in natural seeps.

Perhaps the most abundant supply of natural gas along with salt water comes from the wells lately sunk near the Bascomb race track in Mobile. Recent measurements of the flow of gas of these two wells, have shown it to be 35,000 cubic feet daily for each. As the water gushes from a four inch pipe to the height of six or seven feet it is such a foam of water and gas that it may be ignited and will frequently burn for several minutes till splashed out by chance fall of the water.

The salt wells of Clarke and Washington counties were of great value to the state during the war as source of that indispensable and at the time scarce substance, common salt.

Mineral Waters.

It would be impossible to enumerate all the mineral wells and springs of the state, even those which have a more than local reputation. They are to be found in all parts of the state and show great variety in quality. The following springs and wells either ship water to all parts of the state and outside of the state, or are places of resort with accommodations for visitors: Bailey Springs in Lauderdale County; Chocco Springs, Talladega county; Chandler's and Chambers' Springs also in Talladega; Piedmont Springs in Calhoun; Mentone Springs in DeKalb; all these have waters that are chalybeate or alkaline carbonate. Woolley or Millhouse Spring in Limestone; Johnson well in Madison; White Sulphur Springs in DeKalb; Blount Springs in Blount; St. Clair Springs in St. Clair; Shelby and Talladega Springs in the counties of the same names are all strong sulphur waters. Cullom and Bladon Springs in Choctaw county, were well known places of resort in former years, still much visited on account of their fine sulphur and vichy and other waters. The sulphur well at Jackson, Clarke county, gives a mild saline sulphur water which is not exceeded in palatability by any, unless it be that of a sulphur spring at the Lower Salt works near Oven Bluff.

Many of the artesian borings in the central and lower parts of the state give waters which are much used and which are

sent to all the markets of the state. Livingston in Sumter county is perhaps the best known of these. In the Flatwoods belt on the border of the Cretaceous and Tertiary formations, in Sumter county there are several shallow wells which yield strong *epsom salts* waters that have a wide reputation and are now extensively bottled and shipped. Of the same nature is the water from the Gary Spring near Centerville, in Bibb county, with a composition very nearly identical with that of the celebrated Tate Springs

The Ingram Lithia springs, Cook's Springs and others, have also wide reputation.

The Geological Survey of Alabama is now engaged upon a systematic investigation of the natural waters of the state and many chemical analyses are now available, though not yet published.

Note on Stone Quarries.

In addition to the quarries supplying cut stone for building purposes, mention may be made of quarries supplying rough stone only, viz.:

The *Killebrew Quarries,* two and a half miles east of Berry, Fayette county, on the Southern Railway, supply rough stone for the improvement of the Mississippi River; about 20,000 to 30,000 tons per annum. This quarry is equipped with crushers, and furnish broken stone suitable for ballast.

Messrs. Christie and Lowe, Ledule, Fayette county, also on the Southern Railway, are quarrying the same rock as the Killebrew, viz., sandstone of the Coal Measures, to be used on the jetties of the S. W. Pass, La. This quarry, opened in 1903, has shipped 50,000 tons of stone up to May 15, 1904.

SOILS.

It would be obviously out of place in a document like the present to attempt to give an account of the many soil varieties of the state and their adaptation to various crops. This subject has been treated somewhat in detail in our Agricultural Report, 1881-2.

But inasmuch as the soils constitute the most recent of our geological formations, they must be included among our mineral resources, and certainly no one of these mineral resources can be compared with them in importance and interest to every citizen of the state.

A general discussion of the soils, from the point of view of their geological relations seems, therefore, to be called for here.

Since the soils have been derived from the disintegration and decay of the older rocks, a geological map might, to a certain extent, serve also as a soil map, but these products of decomposition now rarely rest upon the parent rock, but have been removed more or less remotely from their place of origin, and after various admixtures have been redeposited upon foreign terranes with which they have no connection; again, many of the parent rocks of now existing soils have themselves in their turn been soils derived from still older rocks, have been deposited as sediments, compacted, elevated and again disintegrated and decomposed into soils. These are some of the difficulties which we meet with when we attempt to trace a soil back to its origin.

Another difficulty comes from the fact that soils from various sources have often very similar composition, for all soils are essentially the insoluble residues left from the weathering of older rocks, and these insoluble residues, from whatever parent rock derived, are mixtures in varying proportions of sand and clay, with small amounts of the soluble salts derived from these rocks and not yet completely leached out of the resulting soils. It follows, therefore, that soils from whatever source derived, will differ from each other *mainly* in the relative proportions of the sandy or siliceous and the clayey constituents.

It should be borne in mind, further, that in consequence of the highly absorptive and retentive qualities of clay, the relative proportions of lime and of the elements of plant food in the soils, such as potash, phosphates and the like, will in great measure depend upon the amount of the clayey constituent, so that the classification of soils into *sandy* and *clayey* carries with it far more than this primary distinction.

As a broad generalization, it may be said that residual soils, *i. e.*, those which have not been far removed from the parent rock, exhibit the widest variations, while the transported or drifted soils are more uniform in composition. And furthermore, the greater the distance the transported soils have been carried from their place of origin, and the oftener they have been taken up and redeposited, the more complete is the separation of the clayey constituents from the sand, and the more complete is the leaching out of the soluble salts upon which in great measure the fertility is dependent. All this is illustrated in the changes to be observed in the soils as one goes from inland towards the coast.

For convenience in the discussion of its soils, the state may be divided into two parts, approximately coextensive with the Mineral District and the Agricultural District, respectively.

In the first, the soils are in the main, *residual, i. e.,* they have been derived from the rocks upon which they now rest, and show, therefore, more or less close relationship to them. In the second, the Coastal Plain or Agricultural District, the Cretaceous and Tertiary formations have been overspread with a mantle of sandy loam and pebbles, *transported* from elsewhere, and the soils are in great measure made from these materials, modified, however, locally by admixtures with the disintegration and decomposition products of the underlying older rocks.

The Mineral District.

As before stated, the soils of the Mineral District are mostly residual in their nature, and while the parent rocks are sandstones, shales, and limestones, each of these is varied by admixtures with the others, and to such a degree as to give rise to a great variety in the resulting soils. The three principal varieties are here given, but it will be understood that

they grade into each other in such a way that the actual number is far greater.

1. *Sandy Loams, in part slightly calcareous.*—These are derived from the sandstones and siliceous shales of the Coal Measures, the Weisner Quartzite, and the Talladega Slates; from the cherty or more siliceous parts of the Knox Dolomite, and of the Lower Carboniferous Limestones; and from some of the Montevallo Shales. Naturally these soils are less fertile than the others, but on the other hand, they lie well, are easily cultivated and responsive to fertilizers. Perhaps 10,000 square miles of the Mineral region have soils of this kind.

2. *Calcareous Sandy Loams.*—In these the proportion of clay and by consequence, of lime, is greater than in the preceding class; the soils are inherently more fertile, and quite as easy of cultivation and as responsive, and hence form the most desirable farming lands of this section. They cover about 4,000 square miles of territory and are the residual soils from the slightly siliceous limestones of the Tuscumbia division of the Lower Carboniferous, the Fort Payne Chert, the lower beds of the Knox Dolomite, and the more calcareous of the Montevallo Shales, and the rocks of the Red Mountain group. The fine red lands of the Tennessee Valley, those of parts of the great Coosa Valley, and belts in the other anticlinal valleys are of this character.

3. *Highly calcareous clayey soils.*—These occupy some 2,500 square miles of area, and are derived from the purer limestones of the Lower Carboniferous, and of the Trenton, and from the calcareous shales of the Flatwoods. The parent rocks appear along steep hillsides or else in flat, badly drained valleys, and the soils are in consequence generally too rocky or too wet for cultivation; and while essentially fertile, they are of comparative little value as farming lands.

The Coastal Plain.

The upland soils of the Coastal Plain, as has been intimated, are in the main based on the materials of a single formation, the Lafayette, which as a mantle of sandy loam and pebbles has been spread over the entire district with an average thickness of 25 feet. When unmodified by admixtures with

the underlying country rock these Lafayette soils are at their best highly siliceous loams, usually of deep red color from iron oxide. They are well drained, well situated and among the most desirable of our farming lands, because of these qualities and of the ease of working and capability of improvement. At the other extreme they are very sandy and comparatively infertile in the natural state, yet some of the most valuable truck farms of Southern Alabama have soils of this class

While the Coastal Plain formations, Cretaceous and Tertiary, consist prevalently of sands and clays in many alternations, yet there are two great limestone formations intercalated, viz., the Selma Chalk and the St. Stephens Limestone, the former of Cretaceous, the latter of Tertiary age.

The Selma Chalk is about 1,000 feet in thickness, is a rather soft chalky rock carrying from 10 per cent. to 50 per cent, clayey matters, the middle third of the formation holding from 10 per cent. to 25 per cent. of clay, while the upper and lower thirds contain larger amounts.

The St. Stephens Limestone, in its lower part, is also an argillaceous clayey limestone much like the Selma Chalk, but the upper part is a purer rock containing only on an average about 10 per cent. of insoluble matters.

Now in those parts of the Coastal Plain where the underlying country rocks are sands and clays, the resulting soils from these do not differ essentially from the surface loams of the Lafayette itself, and needs therefore no special mention.

But in those belts on the other hand, where the limestones of the Selma Chalk and of the St. Stephens underlie and constitute the country rocks, the soils show marked departure from the prevailing type of Coastal Plain sandy loams. From these areas the Lafayette sands have often been in great part swept away by erosion, and the soils are in a measure residual, being the insoluble clayey residues from the decay and disintegration of the limestones.

Like all clayey soils derived from limestones, they are of exceptional fertility, and make the very best farming lands of the state. Such are the soils of the great Black Belt or Canebrake Belt of Central Alabama, and those of the Lime Hills, and Hill prairies of the southern part of the state. Remnants of the Lafayette mantle occur at intervals through all

these regions, and admixtures of the red loams of this mantle with the native marly soils, give rise to many varieties, such as the *Red Post Oak soils*, the *Piney Woods Prairie soils*, etc.

Another departure from the prevailing Coastal Plain sandy loams is caused by the great clay formation of the Lower Tertiary, which gives origin to the *Post Oak Flatwoods* of Sumter and Marengo counties. East of the Alabama River in Wilcox and Butler counties, these clays hold much lime and form regular "prairie" soils, characteristically developed along Prairie Creek in Wilcox.

Besides the above, there are small areas of marly soils in the Tertiary, due to the shell beds which occur at intervals in the lower or lignitic division of this formation. Of this kind are the celebrated Flat Creek lands of Wilcox, marled by the outcrop of the Woods Bluff greensand shell bed, which is also responsible for fertile lands on Beaver Creek, the same county, on west side of the river, and on Bashi Creek in Clarke county.

The Nanafalia shell bed or marl also is responsible for many tracts of fertile limy soils in Marengo and Wilcox.

In the lower counties of the state the materials of the Lafayette are in general more sandy than is the case further north, and we find in this section also another surface mantle, viz., the Grand Gulf, underlying the Lafayette, and like it consisting mainly of sands with some beds of laminated clay intercalated.

By reason of this double mantle the thickness of the sandy surface beds is much increased, so that the Miocene limestones, which are known to underlie this section, seldom if ever come to the outcrop and influence the soils except along the immediate banks of the Chattahoochee and possibly of some of the smaller streams. In all this region which is gently rolling or nearly flat, shallow ponds, pine barren swamps, and open savannahs are characteristic of the landscape, due, so far as we can make out, to the uneven surface of the Grand Gulf clays which underlie the Lafayette sands at shallow depths These beautifully situated, high, level lands are characteristic of parts of Baldwin and Mobile counties, and are destined to become valuable farming lands when lumbering and turpentining shall cease to give chief occupation to

the population, and this, from present prospects, will soon happen since the pine has been cut off or destroyed by fire over very much of the territory.

Bottom Soils. Along all the larger streams of the Coastal Plain region we find developed normally three well defined terraces. The *first terrace* or bottom is subject to overflow and its soils are the sands and other materials periodically deposited by the stream, and are the most recent perhaps of the formations. A few feet above the high water mark and consequently not subject to overflow except in the depressions caused by erosion, are the *second bottoms,* with very characteristic soils, yellowish silty loams increasing in sandiness from above downwards. The second bottoms are on an average perhaps a mile in width, and are always choice farming lands. Upon this terrace are many of the great plantations of ante bellum days.

About 100 feet above the second bottom we find a *third terrace* averaging some three miles in width, the soils of which are of the usual Lafayette type, red sandy loam underlaid by pebbles. On this terrace are situated most of the river towns such as Tuscaloosa, Selma, Cahaba, Claiborne, St. Stephens, Jackson, Columbia, etc. The soils on this terrace are not essentially different from the Lafayette soils elsewhere, unless possibly they are a trifle more sandy. Above this third terrace at varying elevations are the broad level uplands making the interstream country of the Coastal Plain, and it is upon these uplands that we find the most characteristic and widely distributed of the soils of this region based upon the red sandy loam of the Lafayette.

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